THE UNIVERSITY OF ALBERTA

A LONGITUDINAL STUDY OF THE EFFECTS OF COMPETITIVE ICE HOCKEY ON BOYS 8 TO 11 YEARS

BY

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DEDICATION

This thesis is dedicated to my parents, without whose moral support, my education would not have continued as far as it has.

A mes parents, sans qui mon education n'aurais jamais continue si longtemps.

ABSTRACT

An attempt has been made to longitudinally study a group of boys, beginning at age 8, through several seasons of competitive ice hockey. The present report covers a four year span, i.e. for ages 8, 9, 10, and 11.

The subjects have been members of a team which has averaged 63 games per year. They have been Edmonton City Finalists for two years and City Champions in 1977. Practices for the team have stressed skating and individual puck handling skills over the four year period. Data from a control group was also collected.

Twice yearly evaluations of skating and puck control skills have been made. In addition, annual measures of PWC_{170}, the CAHPER Fitness-Performance items, several anthropometric items as well as grip strength have been taken. Wrist x-rays to estimate skeletal age were taken at the outset of the study.

The results have shown learning curves for the skating and puck control tests which, while typical in nature, demonstrate extremely high levels of achievement for boys of this age. The general fitness results indicate extremely high values when compared to data available from normal populations.

The conclusions reached were that boys involved in a heavy program of competitive hockey, in addition to developing high levels of hockey skill, achieve levels of fitness which are extremely high in relation to published findings from other countries.

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CHAPTER I

INTRODUCTION

Research in ice hockey has been stimulated in the past few years because of defeats at the hands of international competitors who have surpassed Canada (Marcotte, 1974). The scientific approach of other European nations has stimulated research from a physiological point of view (Lariviere, 1974; Bouchard, et al., 1974; Green, et al., 1973; Green, et al., 1976; Green and Houston, 1975) whereas in the past most researchers were interested in the skills aspect of the game (Sabasteanski, 1949; Tower, 1959; Doroschuk and Marcotte, 1965; Hansen, 1970; Brown, 1935; Percival, 1956; Merrifield and Walford, 1969; Merrifield and Walford, 1971). Both aspects of the game, however need further investigation.

Research must also be undertaken in the area of general health and fitness. Some interesting findings have shown us that our nation as a whole is not as fit as others and that people in Canada are not as fit as they could be (Cumming, 1967; Shephard, 1966; Bailey, 1975).

Heart disease is the most serious threat to life in Canada and inactivity has been identified as one of the major contributors (Reville, 1970). In addition, only recently have people become more aware of the need for physical activity to maintain or improve their fitness levels. There are also indications that it can be a preventative and therapeutic combatant of heart disease (Quinney, 1977; Costil, et al., 1974; Ferguson, et al., 1974; Kavanagh and Shephard, 1973). Furthermore, decreases in fitness levels have

been found in children who spend long inactive hours behind school desks after enjoying highly active pre-school years (Bailey, 1973).

The present longitudinal study has attempted to examine the development of fitness and skill in ice hockey in 28 young males aged 8 to 11 in an attempt to shed new light on the aforementioned issues.

Statement of the Problem

The purpose of this study was to longitudinally monitor the development of fitness and ice hockey skills in 28 male hockey players aged 8 to 11 years. The main objectives of the study are as follows:

1. to monitor the development of fitness and ice hockey skills in an experimental and a control group over a period of four seasons of ice hockey.
2. to investigate the effects of summer lay-offs on the retention of ice hockey skills in both the experimental and control groups.
3. to compare the results of the present study to the data reported in the literature.
4. to compare the experimental and the control groups on the development of ice hockey skills.

The tests used to monitor these changes were:

1. the $P.W.C._{170}$ test
2. the C.A.H.P.E.R. fitness performance items
    (a) 50 yard dash
    (b) 300 yard run
    (c) shuttle run
    (d) speed sit-ups

(e) standing broad jump

(f) flexed arm hang

3. grip strength of both the left and right hand

4. a battery of ice hockey skills tests

(a) 60', 90', 120' forward and backward speed skate

(b) Marcotte's modified puck control

(c) Hansen's puck control

(d) forward agility test

(e) Macnab and Gill's backward agility test.

Justification of the Study

Excellence in athletic performance and especially in the sport of ice hockey, since it is our unofficial national sport, should be a concern of all physical educators and coaches in Canada. This nation can no longer claim supremacy in this sport as evidenced by the very fierce international competition given to Canadians in the past few years. Scientific research owes a contribution to the sport. Skills tests are important as a means for the coach to evaluate the effectiveness of his players and of his coaching methods. Furthermore, skating skills such as those used in this study make up the most important components of the sport determining a player's ability.

Fitness tests such as the ones used in the present study are valuable aids in assessing the effectiveness of a hockey program in improving the fitness levels of the children studied and may indicate some of the fitness requirements of a hockey player. Information on the effectiveness of certain activities in improving fitness is needed to further substantiate the position of physical educators

with respect to fitness and physical activity. Little longitudinal data of any kind has been presented addressing itself to the question at hand.

Limitations of the Study

1. The eating habits, off-season activity patterns, as well as outside activities during this season were not controlled.
2. The graphs presented show age groups of 8, 9, 10, and 11 years of age, however, the ages varied making the mean age slightly variable from the ones in the graphs.
3. A small sample was chosen for the study making it difficult to generalize to the normal population.
4. Different testers were used from year to year and motivational levels may have varied from test session to test session throughout the study.
5. Ice conditions changed during the study which may have affected the hockey skills test results.
6. A hockey control group was not included until the third and fourth year of the study, therefore, the boys from the experimental group are compared with the boys from the control group in the last two years only.
7. Pre and post season measures were taken only in the hockey skills tests measures.

Delimitations

1. All subjects from the experimental group were from the same team and from the same community.

2. The same person led the organization and administration of all the ice hockey skills testing sessions, grip strength testing, $P.W.C._{170}$ testing and most of the C.A.H.P.E.R. testing sessions.
3. This study is not a training study. The tests are designed to monitor the development of skill and fitness throughout the four year span.
4. The tests used were subjectively evaluated as tests that were related to the performance of the young hockey players.
5. The comparative data reported in the literature used 8, 9, 10, and 11 years as their age levels. Therefore, if the true means of the present study were used, it could have been impossible to compare the results to other studies.
6. Only post season measures were taken on the fitness items. The same children had been actively participating in this study for four years and it was believed advantageous to the experimenters to demand less of the subjects and their parents to permit the continuation of the study.

<u>Definition of Terms</u>

$P.W.C._{170}$ - a submaximal bicycle ergometer test measuring the physical power output attained by a subject at a heart rate of 170 beats per minute.

MVO_2 or Maximal Aerobic Power - the highest oxygen uptake an individual can attain during physical work at sea

level.

Longitudinal study - study that investigates the same subjects over a number of years.

Cross-Sectional study - a study that attempts to investigate the development of certain parameters over a number of years by taking a sample of subjects at each age level.

Experimental group - a group of hockey players participating in a highly competitive ice hockey league.

Control group - a group of hockey players participating in a recreational hockey league.

Hockey skills tests - the battery of hockey skills tests recommended by Hansen (1970) and Macnab and Gill's backward agility test (Gill, 1977).

Fitness level - level of fitness achieved as determined by a subject's score in a maximal of sub-maximal physical power output test.

Kpm/min - kilograms of weight moved through one meter each minute.

Kilopond - distance through which one kilogram (kg) moves one meter.

p or α - symbol defining the words significance level.

Predicted MVO_2 - estimated MVO_2 determined by extrapolation with a submaximal test.

Retention - retaining or remembering the components of a particular motor skill and how to execute it.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

PHYSICAL WORK CAPACITY

The purpose of this section was threefold:

(1) to examine the use of the P.W.C.$_{170}$ test as a measure of aerobic power.

(2) to examine closely related longitudinal and/or cross-sectional studies of physical work capacity and aerobic power for comparative purposes.

(3) to examine and assess studies that have monitored changes in aerobic power due to training.

Validation of P.W.C.$_{170}$

Some studies have been done to validate the PWC$_{170}$ as a measure of aerobic power (Macnab, *et al.*, 1969; DeVries and Klapfs, 1965; McArdle and Magel, 1970).

Macnab, *et al.* (1969) found a test-retest reliability coefficient of .90 with the PWC$_{170}$. DeVries and Klapfs (1965) found a test-retest reliability coefficient of .818 and a correlation of .877 when the PWC$_{170}$/Kg of body weight was compared to an MVO$_2$ test expressed in ml/kg/min. The standard error of prediction was $\pm$ 4.74 ml/kg/min or 9.4%. McArdle and Magel (1970) obtained a correlation of .80 with the PWC$_{170}$ and an MVO$_2$ test. A poor correlation (.47) was found, however, when MVO$_2$ was not expressed in terms of body weight.

It was suggested that PWC_{170} should be expressed in terms of kpm/kg/min to relate it to body weight, thereby making it a more precise and meaningful measure of work capacity.

Knuttgen (1966) determined the fitness level of male and female adolescents and found a correlation of .86 between the PWC_{170} and an MVO_2 test when PWC_{170} was expressed in terms of body weight.

The PWC_{170} test estimates the work capacity of an individual on the premise that work load and/or oxygen consumption bear a linear relationship with heart rate. Astrand and Rhyming (1954) have shown this to be the case. They have also shown that if higher heart rates were elicited during work, the standard error of prediction decreased from 10.4% to 6.7% in their submaximal test. The PWC_{170} satisfies this criterion of elevated heart rates and therefore it would seem reasonable to assume that the error of prediction would be kept reasonably low.

The PWC_{170} (Howell and Macnab, 1968 and Alderman, 1968) has also been found to be easy to administrate and safe because of its step-wise progression towards a heart rate of 170 beats/min. It also involves a calibrated work load making it possible to determine the exact amount of work done by a subject (Howell and Macnab, 1968).

Comparative Studies

Many studies have attempted to assess the physical work capacity of children by means of longitudinal or cross-sectional studies either to develop norms (Howell and Macnab, 1968) or to compare their group

to others (Dunkley, et al., 1976; Adams, et al., 1961; Adams, et al., 1961, Cumming and Cumming, 1963; Alderman, 1968; Macek and Vavra, 1971 and Cumming and Danziger, 1963). Some of these studies, however, (Alderman, 1968; Macek and Vavra, 1971; and Cumming and Danziger, 1963) have dealt with only one age group or with post-pubertal children. Other studies (Andersen, et al., 1974; Andersen, et al., 1974; Andersen, et al., 1976) have employed direct measures to evaluate the aerobic power of children.

Howell and Macnab (1968) in a cross-sectional study took a random sample of children from across Canada in an attempt to assess the physical work capacity of Canadian children of both sexes from the ages of 7 to 17. A sample of 422 boys from the ages of 8 to 11 were chosen (PWC values presented in Table I at the end of this section with others comparative studies).

Dunkley, et al. (1976) decided to conduct a study in the Grande Prairie elementary public schools to assess the physical work capacity of males from the ages of 6 to 12 years. The sample was not random since the selection procedures depended on parental consent. The study was of a cross-sectional nature designed in this way to attempt the assessment of the physical work capacity of the children in the four elementary schools of that region and to compare them with the data of others.

Some inherent limitations exist in this study. Some of the subjects' body weights were recorded 3 to 11 months after the test was administered. In addition, subjects in two of the schools were tested in March and April of 1976 after a winter of relative inactivity compared to subjects in the other two schools who were

tested in September and October after a summer of greatly increased activity.

Work capacity values of the Grande Prairie study were expressed in kpm/min/kg and in kpm/min. When compared to national norms and international studies values expressed in kpm/min were not found to be significantly different ($p < .05$). When expressed in kpm/kg/min, however, the values of the Grande Prairie children were significantly lower than the Canadian norms and international studies at ages 8 and 11 ($p < .05$).

Adams, et al. (1961) evaluated the physical work capacity of 120 boys and 123 girls from two schools in Los Angeles, California. The children between the ages of 6 and 14 were randomly selected from within the school and this resulted in a sample of 40 boys between the ages of 8 and 11. Vital capacity, height, weight, surface area and a PWC_{170} were the measures that were taken. The bicycle test consisted of three, six minute work loads with each workload being set to achieve a heart rate of between 100 and 120 beats/min after the first workload, 120 to 140 after the second and 150 to 170 after the third. Heart rates and workloads were plotted on a graph and the estimated workload producing a heart rate of 170 beats/minute was taken as the physical working capacity of the subjects. Physical work capacity, expressed in kpm/min correlated well with weight (.81), height (.83), surface area (.81), age (.79) and three second timed vital capacity (.62).

Adams, et al. (1961), in a subsequent study, repeated the procedure of the previous study to assess the physical work capacity of

Swedish children. The age range was narrowed to between 10 and 12 years of age and heart volume was measured in addition to the measures taken in the previous study. A sample of 63 boys was chosen. In addition, 22 boys were retested to see if the summer holidays had any effects on work capacity. Of the 22 boys, 16 improved or showed no change in work capacity and six showed a decrease in work capacity. Paradoxically, correlations of work capacity with morphological variables were low (r = .37 to .57) when compared to the findings in the California study.

In another phase of the study, subjects were divided into three groups; highly trained, moderately trained and poorly trained. The highly trained individuals' work capacity was 676 kpm/min whilst the work capacity of the untrained individuals was 485 kpm/min.

Cumming and Cumming (1963) studied the physical work capacity of Winnipeg school children from the ages of 6 to 16 years. Both sexes were tested and a selected sample of 112 children resulted. Twenty boys aged 8 to 11 years were tested. In this part of the study, correlations between surface areas (.904), height (.865) and weight (.897) were found with the PWC_{170} test.

The second phase of the study looked at four different schools in Winnipeg to see if different physical education programs yielded variability in work capacity of grade five and grade six children. Three schools that offered two 30 minute periods of physical education per week and one private school that offered two classes, two competitive game periods and organized team sports were included for a total of 88 tested children. There were 20 boys from the private school and 23

from the other schools. The physical work capacity of the boys from the private school was greater (450 kpm/min) than the children from the other schools (384 kpm/min.).

All physical work capacity values in kpm/min and kpm/min/kg, weight, height, and the size of the sample of all the previously reviewed studies are presented in Table I.

Training Studies

Many studies have been done (Wilmore, et al., 1970; Sharkey, 1972; Pollock, et al., 1969; Durnin, et al., 1960; Ekblom, et al., 1968; Frick, et al., 1963; Jackson, et al., 1968) to investigate the effects of training on cardiorespiratory endurance in adults. In these investigations such changes as an increased MVO_2, total work, maximum ventilation, arterio-venous oxygen difference, oxygen pulse and decreased lactic acid levels, resting heart rates, and diastolic and systolic blood pressures have been found.

Some studies (Macek and Vavra, 1974; Gadhoke and Jones, 1969; and Godfrey, et al., 1970) examined the cardiorespiratory responses to exercise in children as compared to adults. Results from these studies indicate that on parameters such as heart rate, lactate production, oxygen consumption, cardiac output (Q), stroke volume, ventilation, and respiratory quotient children react in much the same way as adults during steady state or maximal work. In children, maximal heart rates were higher and tidal volumes were smaller than those of adults. This is not surprising since these parameters are related to size and age.

TABLE I

Physical Work Capacity of Selected Populations

Population	Age	Height (cm)	Weight (kg)	PWC_{170} kpm/min	PWC_{170} kpm/min/kg	N
Canada (Norms)	8	--	27.7	351.0[a] $\pm$ 92.0	12.71 $\pm$ 2.94	101
Sweden	8	--	--	--	--	--
California	8	131.0	30.0	438.0	14.60	11
Grande Prairie	8	--	29.5	314.8	10.70	37
Winnipeg	8	132.0	30.0	457.0	15.20	5
Canada (Norms)	9	--	30.5	384.7 $\pm$ 90.1	12.73 $\pm$ 2.75	119
Sweden	9	--	--	--	--	--
California	9	140	35.0	472.0	13.50	10
Grande Prairie	9	--	33.9	398.4	11.90	36
Winnipeg	9	139	34.0	435.0	12.80	5
Canada (Norms)	10	--	33.7	427.1 $\pm$ 95.1	12.79 $\pm$ 2.23	101
Sweden	10	141.5	34.5	500	14.50	25
California	10	145.0	40.0	551	13.78	9
Grande Prairie	10	--	35.5	425.1	12.10	37
Winnipeg	10	139	34.0	458	13.50	5

(continued)

Population	Age	Height (cm)	Weight (kg)	PWC_{170} kpm/min	PWC_{170} kpm/min/kg	N
Canada (Norms)	11	--	37.7	493.6 $\pm$ 129.2	13.21 $\pm$ 3.11	121
Sweden	11	147	37.5	596.5	15.90	38
California	11	152	46.0	650	14.13	10
Grande Prairie	11	--	41.6	474.8	11.60	29
Winnipeg	11	142	34.0	474.0	13.94	5

Mean $\pm$ standard deviation

It would seem logical that training should have the same effects on children as in adults, however, the added variable of growth in children has led to disagreement regarding whether or not training can increase work capacity beyond the expected changes due to growth.

Cumming, et al. (1967) performed a study in a youth's summer track camp with six boys and six girls 13 to 16 years of age. The training that the children undertook at this one week track camp included a total of 35 to 45 miles of running per day as measured by a pedometer. The researchers decided to do repeated measurements on these children to see the changes in heart rate, oxygen consumption and morning and evening submaximal workloads on a bicycle ergometer.

The first six minutes of the exercise test was designed to achieve a heart rate of 170 beats/min. A subsequent increase of 100 kpm was used to elicit a maximal effort and measurement of MVO_2. On the following days, if necessary, workload was increased an additional 100 kpm if the subject could pedal at that workload for three minutes.

Cumming and his co-workers did find changes in the behavior of submaximal heart rates to a given workload. These heart rates, along with maximal heart rates, decreased significantly. In girls, submaximal heart rates decreased from 148 to 145 and from 161 to 160 beats/min in the boys ($p < 0.05$).

The MVO_2 of the boys and girls did not change significantly, however, the high means (65.0 ml/kg/min for boys and 49.0 ml/kg/min for girls) of these individuals offer much less room for improvement

so that great increases would not be expected. Furthermore, one week of training is likely too short a period of time to see changes in MVO_2. Nevertheless, with a constant MVO_2 and a decrease in maximal heart rates, there is an obvious increase in oxygen pulse which would indicate a more efficient cardiovascular system during submaximal work. It was thought by Cumming and his co-workers that the decrease in heart rates after a week of testing could indeed be because of improved efficiency both mechanical and cardiovascular or that there was a lessened anxiety in the subjects at the time of testing.

Cunningham (1976) investigated the PWC_{170} and the MVO_2 of 15 ten year old hockey players from a competitive league in London, Ontario. These children played 60 games per year, had 40 practices and placed third in London, Ontario. Cunningham found that the PWC_{170} of these children ranged from the 76th to the 83rd percentile when compared to the Canadian norms.

Continuing the work to a maximal effort, it was determined that the MVO_2/kg values (56.6 ml/kg) was comparable to adult hockey players from the University of Western Ontario. When compared to children of the same age from other studies, he found his children to be superior except in the case of Astrand's children who had about the same values (Astrand, 1952). Lactate values in this study, however, were lower than expected yielding a mean of 53 mg%. These relatively low values were attributed to motivational problems encountered when performing maximal tests in children. One general conclusion of the study was that playing hockey seems to keep children more fit than the normal population.

Massicotte and Macnab (1974) decided to investigate the effect of three different intensities of training on the aerobic power of 36 boys 11 to 13 years of age. The training sessions lasted six weeks with heart rate, lactate levels, MVO_2, height, weight, O_2 pulse, ventilation being measured before and after training. Fitness levels were assessed prior to training and all 36 subjects were divided into three blocks, then reassigned randomly to one of four training groups. The first group trained at a heart rate of 170-180 beats/min; the second at 150-160 beats/min; the third at 130-140 beats/min with the fourth group acting as a control. All training sessions were performed for 12 minutes three times per week on a bicycle ergometer.

The bicycle ergometer test was an intermittent test consisting of four minute workloads with five minute rest periods starting at 450 kpm with subsequent 150 kpm/min workload increases until exhaustion. Gas analysis was done by the Douglas bag technique. Lactates were taken 45-60 seconds after each workload from a finger-tip blood sample.

All three training groups decreased their submaximal heart rates by 16, 12, 16 beats/min respectively. There was no significant difference between the three groups on this parameter ($p < 0.05$). At a submaximal workload, the highest intensity training group decreased their lactate values by 20% significant at $p < 0.05$. No other changes took place during submaximal work.

All three training groups increased their total work output by 25, 23, and 21% respectively. Maximal lactic acid concentration in

the blood during exercise increased by 21% in the high intensity group. In addition, this group increased its MVO_2 by 11% with an accompanying 13% increase in maximal oxygen pulse, both significant at $p < 0.05$. There were no comparable changes in the other training groups or the control group. Massicotte and Macnab advocated training at a heart rate of 170 beats/min or 75% of maximal heart rate for optimum improvements in MVO_2 in children.

Seliger, et al. (1974), taking similar measures, investigated the effect of habitual activity patterns on these parameters in a group of 11 and 12 year old boys. Seliger discovered that these boys' activity patterns reflected those of sedentary children. When values for oxygen pulse, MVO_2/kg of body weight and lactate values were compared with the children in Massicotte and Macnab's (1974) study, it was determined that Seliger's children were lower on all parameters; (8.6 vs. 10.4) for oxygen pulse, 41.8 vs. 51.8 for MVO_2 in ml/kg/min, and 68 mg% vs. 86.8 mg% for lactate values).

Sprynarova (1974) investigated the effects of a physical activity program on healthy boys aged 11 to 18 years. Thirty-nine children were divided into three groups. The first group consisted of eight children who trained regularly four hours per week until the age of 15 and six hours until the age of 18. In the second group, there were 19 boys who trained regularly two hours per week until the age of 15 and three hours thereafter until the age of 18. Finally, in the third group, 12 boys trained one hour a week until the age of 15 with no further training.

The first group started at a level comparable to the other two groups in MVO_2. The three groups started in the range of 44.0 to 48.5 ml/kg/min, the lower value being that of group three and the higher value being that of group one and two. At the end of the study the first group had progressed to 54.5 ml/kg/min while the second and third groups remained relatively unchanged at 49.5 ml/kg/min and 45.0 ml/kg/min respectively.

It is interesting to note here that in the case of all three groups the greatest increases occurred during the ages of 13 to 15 during the adolescent growth spurt followed by a subsequent decline until the boys were 17 years of age. In this study, it would appear that the children were most susceptible to training during the pubertal period since an increased amount of training did not seem to have as much effect after the growth spurt as less training during the growth spurt.

Cunningham and Eynon (1973) compared the fitness levels of highly trained swimmers varying in age from 11.0 to 14.9 years to results from other studies and to adult swimmers. The subjects were randomly selected from 50 Ontario swim teams, a total of 43 subjects being chosen (19 females, 24 males). The tests were taken after a summer of intensive training five times per week with the distance swam per session varying from 2,118 to 3.194 yards. In addition, four university swimmers of international calibre were tested.

Physical work capacity, MVO_2 and lactate values were all measured while subjects worked on a bicycle ergometer. An intermittent test was used and gas analysis was accomplished by the Scholander technique.

Physical work capacity expressed per kilogram of body weight ranged from 18.76 to 21.63. These results were greater than those of the Canadian norms and other age matched studies. When the children were compared to the older swimmers they were similar since the older swimmers had a physical work capacity value of 19.6 when expressed in terms of body weight. MVO_2 expressed in terms of body weight yielded values ranging from 52.9 to 56.6 ml/kg/min, comparable to the older swimmers who had a value of 55.9 ml/kg/min. In the younger swimmers, it was felt that MVO_2 values were not attained because of the nature of bicycle ergometry. Furthermore, lactate values in the younger children were lower ranging from 81 mg% to 108 mg% while in the older swimmers, a value of 148 mg% was obtained.

Running training and its effect on growing boys' MVO_2 was studied by Daniels and Oldridge (1971). A total of 14 children 10 to 15 years of age were studied for a period of 22 months. The children trained by running anywhere from 750 to 2000 miles per year. Every six months the children were tested. Submaximal and maximal gas analyses were made with a Gallenkamp apparatus. The boys practised running on a treadmill before actually doing the test. The endurance test proceeded in this manner: four minutes of submaximal work at 202 meters/min; the speed being calculated according to the runners' times; the runners' best two mile race pace for three minutes followed the first run. If the runners had not reached exhaustion at this point a subsequent three minute run at the runners' best one mile race pace followed.

After 22 months, there was an increase in MVO_2 of 22% from 2.331

to 2.839 litres/min. When expressed in ml/kg/min, there was no change, this value remaining at 59.5. One other interesting finding was observed when the group was split into two types; the hard runners and the easy runners. Those who were termed hard runners maintained a higher MVO_2/kg throughout the study than did the easy runners, however, the easy runners had a lower VO_2/kg during submaximal running. While running at the same pace as they did at the beginning of the study, the energy costs of the easy runners decreased by 3.9 ml/kg/min. This was shown by a decreased O_2 pulse during the submaximal runs.

Daniels and Oldridge found, therefore, no increase in absolute MVO_2, but an increased efficiency of the cardiovascular system during submaximal work in the easy runners. It seems, however, that training in this and other studies that have been reviewed was not carefully controlled. The intensity of training may not have been adequate in order for favourable changes to take place.

Ekblom (1969) studied six boys 11 years of age who trained for six months. Another group of seven boys of the same age who did not train acted as a control group. Both groups were matched on height, weight, vital capacity, MVO_2 and heart volume at the beginning of the study. The groups were measured at the beginning of the study, after six months training and at the end of the study. Table II depicts the type and amount of training during the first six months.

After the first six months seven of the boys (two from the control group) continued to train for a further 26 months. The training program consisted of handball, bandy, ice hockey and soccer for 45 minutes three times per week. In addition, they had regular school

TABLE II

Training Regime in Ekblom's Study

Type of Training	No. of Training Sessions
Interval Training 3-4 x 1,000 m., 80-90% full speed	17
Dash Training 10-20 x 75 m., full speed	13
Distance Training 4-5,000 m., steady speed cross country	9
Strength Training circuit and weight training	5
Ball Games soccer, ice hockey, 45 min.	9

training which consisted of calisthenics and ball games two times a week for 45 minutes.

These boys increased their MVO_2 by 55% after 32 months training from 2.22 to 3.45 l/min. The control group on the other hand increased their MVO_2 by 37% from 1.85 l/min to 2.54 l/min. When expressed in ml/kg/min, however, the increase in the training group was in the order of 3% from 55.9 to 57.5 ml/kg/min while in the control group the increase was in the order of 2% (53.3 to 54.1 ml/kg/min). The rate of change between the two groups may not have been that different, however, the magnitude of the change was greater in the experimental group since they began at a higher level. The training group increased their body weight by 8.6 kgs. The heart volume of the training group increased by 48% from 480 to 710 ml in the training group and by 37% from

425 to 580 ml in the control group. The vital capacity of the training group increased by 54% from 3.20 to 4.45 litres while in the control group, the increase was in the order of 34% from 2.51 to 3.37 litres. Submaximal workload heart rates of the training and control group went from 147 and 156 to 118 and 139 respectively at 450 kpm/min and from 129 and 136 to 102 and 122 at 300 kpm/min. There is an obviously greater improvement in the training group when compared to the control group on this parameter indicating a more efficient cardiovascular system in the training group.

It is interesting to note that on all parameters, the training group's increase was greater. When looking at the raw data it would seem that these increases are not that significant, however, the training group begins at a higher level than the control group on all parameters, therefore, the expected change would logically be less or equal to the control group's change under normal conditions since there is less room for improvement in the training group. One explanation that was offered for the greater increases in the training group was that perhaps the growth hormones are stimulated by physical training and that subsequently growth is accelerated to a greater extent than under normal conditions.

Andersen (1976) investigated the growth of maximal aerobic power in 65 Norwegian boys and girls from the Lom community. The testing began at age 8 ($\bar{x}$ = 8.3) and continued throughout four years until age 12 ($\bar{x}$ = 12.2) each yearly testing session occuring in the fall (September to October). During that time, new facilities including a swimming pool and gymnastics halls were built and fitness surveys were in pro-

gress. These factors were thought to improve attitude toward fitness, physical education curriculum and out of school sports activities. The number of subjects tested each year are presented in Table III.

TABLE III

Number of Subjects Tested in Andersen's Study

	Boys	Girls
Year 1	N = 29	N = 33
2	N = 29	N = 33
3	N = 31	N = 34
4	N = 29	N = 34

Physiological parameters tested were heart rate (maximal), oxygen pulse, ventilation, tidal volume, respiratory quotient MVO_2, height, weight, and percent body fat.

On all parameters except for maximal heart rate and percent body fat (which did not change), increments were seen. MVO_2 expressed in terms of body weight went from 52.7 ($\pm$ 3.93) to 58.0 ($\pm$ 7.95) in the boys and from 47.4 ($\pm$ 7.01) to 53.6 ($\pm$ 6.87) in the girls.

No significance tests were performed on any data and differences on other parameters were too small to be considered significant, however, MVO_2/kg did show a considerable increase over the four years. One of the reasons given for the increase in the general fitness of the children (as measured by MVO_2) that was suggested was the improved physical education facilities and attitude towards physical fitness in

the community.

Mirwald (1973) investigated the development of maximal aerobic power of 51 boys aged 8 to 15 years from the Saskatchewan growth and development study. In addition, to assess the representivity of that sample to the normal poulation, a cross-sectional sample was tested. This resulted in an additional sample of 378 boys. All the subjects tested were normal, healthy and untrained. In addition to MVO_2, height, weight and lean body weight (assessed by skinfold measurements) were measured.

A continuous treadmill test for the determination of MVO_2 was used. The subject walked for three minutes at three m.p.h. This was followed by three minute runs at six and nine m.p.h. and finally at 12 m.p.h. until exhaustion.

Results indicated stability of MVO_2 over the first four years of the study. The sample from the growth study was comparable to the cross-sectional sample taken. The MVO_2 of the boys from the growth study varied from 57.24 ($\pm$ 4.98) at age 8 to 57.18 ($\pm$ 4.31) at age 11 while in the cross-sectional sample, the MVO_2 values recorded were 56.03 ($\pm$ 5.93) at age 8 to 55.2 ($\pm$ 5.37) at age 11. The values remained fairly constant throughout this time span (four years) and it was suggested that the idea of increased fitness with increased age was unprecedented.

Shephard (1966) in a study presented mean values of MVO_2 in ml/kg/min from different countries. Three countries (Canada, U.S.A., and Scandinavia) had values for children from 8 to 12 and these values

along with the values of Mirwald and Andersen are presented in Table IV.

Another aspect that must be taken into consideration when looking at training studies is heredity. As early as 1963, Astrand proposed that training in the early years of life had a potentiating effect on the functional dimensions of girl swimmers. When he compared the 30 trained swimmers to normal healthy untrained girls of the same size, it was found that the trained girls were superior on functional dimensions such as MVO_2, heart volume, total hemoglobin, lactate concentrations, ventilation by as much as 11 to 15 percent. Correlational analyses revealed that vital capacity, total hemoglobin, heart volume, maximal heart rate and lactate concentrations accounted for 80% of the variance with an MR = .930.

One limitation of the study, however, was that all the athletes were hand picked from the best swim clubs in Stockholm, Sweden. Other athletes of lower calibre were not compared to untrained girls. How representative the top athletes are of athletes in general cannot be elucidated from this type of sampling.

Klissouras (1971), using a technique reported by Vandenberg (1965), attempted to establish the contribution of heredity to the limit of functional adaptability with a heretability estimate. The following equation was used:

$$H \text{ est} = \frac{(\sigma^2 D_Z - \sigma^2 D_{ZM}) - (\sigma^2 MZ - \sigma^2 MZ_M)}{(\sigma^2 DZ - \sigma^2 DZ_M)} \times 100,$$

where error variance was hopefully explained in an actual experiment therefore leaving only the variance explained by heredity.

TABLE IV

Mean MVO_2 Values of Different Populations (ml/kg/min)

Age (Years)	Andersen Study	Mirwald Study		Shephard		
		1	2	*Canada	U.S.A.	Scandinavia
8	52.7 $\pm$ 3.93[a]	57.24 $\pm$ 4.98	56.03 $\pm$ 5.93	56.0	52.7	55.0
9	54.5 $\pm$ 5.23	60.17 $\pm$ 6.00	56.35 $\pm$ 5.99	56.0	52.7	55.0
10	60.0 $\pm$ 6.48	57.54 $\pm$ 4.69	55.84 $\pm$ 5.94	53.9	47.1	59.5
11	56.9 $\pm$ 6.14	57.18 $\pm$ 4.31	55.20 $\pm$ 5.37	53.9	47.1	59.5

a - denotes standard deviations
1 - denotes growth study sample
2 - denotes cross-sectional sample

* Countries were grouped as 8-9 year olds and 10-11 year olds. This is the reason for repeated $\bar{x}$ values.

Klissouras compared 10 sets of dizygotic twins (DZ) and 15 pairs of monozygotic twins (MZ) to see if any difference existed in MVO_2, ventilation, respiratory rate, tidal volume, respiratory quotient, heart rate, and blood lactates concentrations. Monozygosity and dizygosity were established morphologically and with serological examinations.

The difference between DZ and MZ twins was significant ($p < .01$), however, MZ twins and DZ twins were not significantly different from each other within their own groups.

The heritability estimate's validity was based on two underlying assumptions. First, that the environmental stimuli were comparable for both the MZ and DZ twins and second, that no genetic-environmental interaction was present. The children were reared in the same city at an early age and therefore environment was thought to play a relatively small role at this age. In regard to the second assumption, it was suggested that studies comparing training twins versus non-training twins would further reveal the possible interaction between heredity and training. Klissouras concluded that in a fairly homogeneous group such as this that heredity seems to account for most of the variance in MVO_2.

In a later study, Klissouras (1972) investigated the effect of training in a monozygous trained twin versus his untrained brother over a period of one and a half years. Monozygosity was established in the same manner as in the previous study.

MVO_2, O_2 consumption during submaximal work, blood lactates, heart rate, stroke volume, a-VO_2 difference, ventilation, respiratory

rate, tidal volume, respiratory quotient, O_2 pulse, work efficiency were all examined in both twins. Measurements were taken at four different times during the 17 month period.

Both twins had been very active from the ages of 8 to 15 years, participating in sporting events throughout this time. One of the two became interested in cars, became a car salesman and thereafter led a sedentary life. The other twin maintained his interest in sports and athletic endeavours and participated and trained strenuously throughout high school and university where he was a physical education student playing football and ice hockey.

At none of the sessions were the twins significantly different ($p < .01$) except in the case of MVO_2 where the trained twin had an MVO_2 of 49.2 ml/kg/min which was 37% greater than the 35.8 ml/kg/min of the untrained twin.

It is of interest to note here that despite this prolonged period of training, the active twin was unable to exceed an MVO_2 of 49.2 ml/kg/min during the 17 month period suggesting a ceiling or limit to his functional adaptability which in view of the previously reviewed studies suggests that this limit is genetic.

Weber, et al. (1976) studied four sets of 10, 13, and 16 year old monozygotic twins on the same parameters as in the previous two studies. One twin trained while the other acted as a control. In the case of 10 and 16 year old twins, MVO_2 was significantly greater in the training as compared to the untrained twin brother. The 13 year old untrained group increased their MVO_2 as much as the trained and this was attributed to the effect of the growth spurt on the development of

functional dimensions at this age.

The training program lasted for 10 weeks with a subsequent one year analysis of some of the twins which revealed a similar pattern in the development of functional dimensions as the 10 week study. Applying the same formula in an analysis of variance revealed that the main cause for the difference in MVO_2 even with training was still genetic predisposition. Training, however, was an important variable accounting for 42% of the variance as compared to 51% of the variance predicted by genetic predisposition. The interaction between the two accounted for 7% of the variance.

The statistical methods used by Klissouras and his co-workers in the previously reviewed studies, however, is not well explained and needs further study before conclusions can be drawn from such data. Further discussion of heredity is beyond the scope of this study and the reader is referred to a paper by Gionet (1977) for a more detailed summary of the relationship between heredity and functional adaptability.

C.A.H.P.E.R. FITNESS PERFORMANCE ITEMS

The purpose of this section was to review the paucity of studies that deal with some, all, or similar performance items to those incorporated in the C.A.H.P.E.R. battery.

In 1966 Hayden and Yuhasz published a project designed to establish fitness norms for Canadian boys and girls from 7 to 17 years of age. The performance items were selected with time, equipment and personnel limitations in mind.

A total sample of 11,000 subjects were randomly selected. This resulted in a sample of approximately 2,125 boys aged 8 to 11 being tested in the following items: speed sit-ups, standing broad jump, shuttle run, flexed arm hang, 50 yard dash and 300 yard run.

Ellis, et al. (1975) presented data examining the development of the flexed arm hang, sit-ups and standing broad jump in boys 10 to 16 years of age. The data were from the Saskatchewan Growth and Development study. The purpose of the study was to look at the rate of growth and the improvement. A sample of 106 boys randomly selected from the elementary school systems was used for this study.

Cumming and Keynes (1967) conducted a study on 497 boys and girls aged 7 to 17 to attempt validation of the C.A.H.P.E.R. performance items with an MVO_2 test and the PWC_{170}. The sample was not randomly selected. Boys and girls were taken from grades one through twelve.

All the children underwent a PWC_{170} test and the test was merely continued until the subjects were exhausted, the criterion for MVO_2 being failure of an increased work load to produce an increased oxygen consumption. In addition, all of the subjects completed the C.A.H.P.E.R. performance items and height and weight were measured. Body surface area was calculated, however, the method of calculation was not explained.

Results were intercorrelated and multiple correlations were also calculated to find the best prediction equation of MVO_2 by the performance items. Correlations of the performance items with PWC_{170} and MVO_2 varied from .42 with sit-ups to .76 with the broad jump for the boys. A multiple correlation of .82 with MVO_2 (accounting for 67% of

the variance) for the boys was found when the C.A.H.P.E.R. items and surface area were combined, however, the data for this correlation came from a large but very heterogeneous sample explaining in part the seemingly good correlation.

Much data was collected, however, and these data were used for comparative purposes in this study along with the data of Ellis and Bailey and that of the national study. These data are presented in Table V at the end of this section.

Olree, et al. (1965) attempted to evaluate the validity of the A.A.H.P.E.R. battery by correlating the items from the battery to MVO_2. A total of 76 subjects aged 16 to 17 years of age were subjected to a maximal treadmill test and to the A.A.H.P.E.R. battery. The subjects were ranked according to the percentiles of the norms and it was determined that they ranged from 50 in the 50 yard dash to 67 in the 600 yard run, the subjects therefore being average or above average in all performance items. The mean MVO_2 was 44.9 ml/kg/min and was, therefore, average relative to Astrand's classification.

Correlations varied from .226 with the sit-ups to .532 with the 600 yard run. A multiple correlation combining the 600 yard run, shuttle run and the 50 yard dash yielded an $R = .615$ which accounted for only 36% of the variance. It was, therefore, concluded that the battery of tests was not a good prediction of MVO_2.

Falls, et al. (1966) also attempted to investigate the validity of estimating MVO_2 from the A.A.H.P.E.R. youth fitness test battery in 87 men from 23 to 58 years of age. The subjects were from the staff and faculty of Purdue University. In addition to the performance items,

the medicine ball put replaced the softball throw and a drop-off index (which was the difference between the 600 yard run time and the 12 x 50 yard time) was added. Sit-ups were limited to a maximum of 50.

A maximal test was performed on a bicycle ergometer. Lean body mass was estimated with a whole body scintillation counter. Pearson product moment correlations and multiple correlations were used to find the best predictors of MVO_2.

The multiple correlation between MVO_2 and the performance items yielded an R of .760 which explains 58% of the variance. When some of the items were dropped and only pull ups, 50 yard dash, 600 yard run and the shuttle run were included an $R = .764$ or $R^2 = .52$ was found. With such a large age range, however, it is not surprising to find a reasonable correlation with MVO_2. In addition, they used the 600 yard run which is not part of the C.A.H.P.E.R. battery, making it impossible to compare. Furthermore, they were working with adults which would eliminate many discipline and motivational problems that would have to be dealt with when testing young children.

Docherty and Colliss (1976) attempted to test the internal validity of the C.A.H.P.E.R. performance items with a sample of 55 boys and girls from the ages of 8 - 12. The items were correlated to the PWC_{170} and PWC_{170} expressed in terms of body weight.

Correlations with PWC_{170} varied from .058 with the 300 yard run to .211 with the flexed arm hang. When PWC_{170} was expressed in terms of body weight, correlations improved only slightly to -.168 in the 300 yard run and to .454 with the flexed arm hang. The 300 yard run was judged as an inadequate measure of aerobic capacity. The researchers

found high intercorrelations between the performance items (.510 to .865) which suggests that some of the measures depict essentially the same or similar components of fitness. The elimination of some of the measures was offered as a solution to this problem and brought forth the idea of a modified battery. The battery suggested included the flexed arm hang, speed sit-ups, the standing broad jump and a one and one half or one mile run as an indicator of aerobic capacity. The 300 yard run, the 50 yard dash and the shuttle run were replaced by the longer run. The runs, along with the standing broad jump, were all postulated to be measuring leg strength because of the high intercorrelations.

Crawford and Mason (1974) tested the reliability of the C.A.H.P.E.R. fitness performance items. In this study 80 boys 13 years of age performed the C.A.H.P.E.R. fitness items. In the first part of the study 37 subjects were involved in a simple test-retest reliability coefficient calculation for each item in the battery. The children were randomly assigned to each item so that there would be no order effect. These coefficients varied from .419 in the 300 yard run to .803 in the speed sit-ups.

In the second part of the study, motivation was added to see if this would improve the reliability of the performance items in 40 other subjects. Motivation was implemented by the following different methods:

(1) promising profile of results to each student

(2) subjects received hand-outs containing percentile norms

and scores of top three subjects from Part I

(3) wall charts were posted in the gymnasium

(4) after Test #1 results were posted

(5) verbal encouragement was provided at all times

(6) during runs there were two subjects sent at a time to provide competition

(7) increased number of trials.

Reliability coefficients generally increased ranging from .725 in the sit-ups to .821 in the 300 yard run. The reason given for the decrease in the coefficient of reliability in the sit-ups was that a group of boys counted the sit-ups performed rather than using the buddy system as in Part I of the study. Motivation was attributed as the main reason for the increased reliability of the measure.

Rothermel, et al. (1968) conducted a study in an established summer day school. The boys' activity program at this summer school consisted of an activity phase and a testing phase. The activity phase included three hours of activity every afternoon for five days each week for eight weeks. Testing included three hours every morning in five mornings.

Although the A.A.H.P.E.R. youth fitness manual is composed of tests that are different procedurally and technically than the C.A.H.P.E.R. battery, there are some similarities and it was thought interesting to look at this study to get an idea of the effect of increased activity levels on such parameters.

A total of 87 boys from the ages of 7 to 13 years were tested, 65 making up the control group. Both groups were tested at the same time before and after the experiment began. Subjects were selected on a

volunteer basis. Statistical analysis included t-tests (< .05) and test-retest reliability.

Test-retest reliability coefficients were done on the experimental group and this was the only time that the experimental group had more exposure to the performance items than did the control group. The coefficients varied from .86 in the shuttle run to .95 in the standing broad jump. In the means after eight weeks, sit-ups, pull-ups, standing broad jump and the 600 yard run were significantly different (< .05) in the experimental group while in the control group there was no change. In the 50 yard dash, shuttle run and the softball throw there was no difference in either group (< .05) before or after eight weeks.

They concluded that in measures of muscular and cardiovascular endurance the experimental group progressed to a greater extent while in the other measures which purport to measure speed, agility, and coordination there was no difference.

GRIP STRENGTH

Everett and Sills (1952) investigated the relationship between grip strength to stature and somatotype components and anthropometric measures of the hand. Using 400 subjects varying in age from 14 to 29 years and a hand grip dynamometer, zero-order correlation coefficients were calculated for height, weight and age and grip strength, these being .60, .66 and .47 respectively. Everett and Sills concluded that age had little influence on grip strength. This was demonstrated when partial correlations were done by holding other variables constant. The partial correlation between age and grip strength was low. Of all

TABLE V

C.A.H.P.E.R. Fitness Performance Items

Achievement Scores

Study	Age	N	50 Yard Dash (secs)	300 Yard Run (secs)	Standing Broad Jump (inches)	Flexed Arm Hang (secs)	Speed Sit-Ups (No. in 1 min.)	Shuttle Run (secs)
C.A.H.P.E.R. 1964	8	575	9.7	81.0	48.0	29.0	23.5	13.5
Ellis and Bailey 1975	8	---	---	---	---	---	---	---
Cumming and Keynes 1967	8	47	9.3 ± 1.6	77 ± 5	51 ± 5	27 ± 19	27 ± 10	13.0 ± 1
C.A.H.P.E.R. 1964	9	525	9.3	77.0	52.0	31.0	26.5	13.0
Ellis and Bailey 1975	9	---	---	---	---	---	---	---
Cumming and Keynes 1967	9	40	8.9 ± 1.1	76 ± 9	52 ± 5	27 ± 16	29 ± 9	12 ± 1

(continued)

Study	Age	N	50 Yard Dash (secs)	300 Yard Run (secs)	Standing Broad Jump (inches)	Flexed Arm Hang (secs)	Speed Sit-Ups (No. in 1 min.)	Shuttle Run (secs)
C.A.H.P.E.R. 1964	10	490	8.8	73.0	53.0	32.5	27.4	12.8
Ellis and Bailey 1975	10	*106	---	---	66.4	30.6 ± 19.9	37.8 ± 10.2	---
Cumming and Keynes 1967	10	10	9.1 ± 0.5	80 ± 13	58 ± 7	19 ± 11	29 ± 9	13 ± 1
C.A.H.P.E.R. 1964	11	470	8.5	72.0	58.0	34.5	30.4	12.4
Ellis and Bailey 1975	11	106	---	---	66.7	36.1 ± 22.9	39.4 ± 10.5	---
Cumming and Keynes 1967	11	20	8.5 ± 0.7	71 ± 5	62 ± 8	31 ± 20	35 ± 8	12 ± 1

*Total N for both years is 106.0

the variables, weight correlated the highest, accounting for 44% of the variance when zero-order correlations were done. When partialled out, it caused the greatest decrease in correlations between grip strength and other variables. The researchers warn us of making any conclusions from zero-order correlations, however, since too many other factors may be involved and one factor cannot account for all the components of grip strength.

Pierson and O'Connell (1962) were also interested in the relationship of age, height, weight and grip strength. A total of 299 healthy males varying in age from 20 to 34 years were studied. The sample was heterogeneous coming from four distinct groups, these being policemen, recruit policemen, members of athletic teams and students in body conditioning classes.

Weight yielded the highest r's, these being .43 and .42 for the right and left hand grip, respectively. Height correlated only moderately and insignificantly at .27 for both hands. Age was found to have an even lower relationship with grip strength with r's of .18 and .20.

The conclusion was that weight was moderately correlated to grip strength whereas height and age were not related to grip strength.

Tinkle and Montoye (1960) conducted a similar study as in the previous two investigations also looking at the relationship of age, height and weight to grip strength, however, they also attempted to relate grip strength to achievement in physical education. A total of 635 freshmen and sophomores enrolled in activity classes at Michigan State University were randomly selected for the study. The grading system at the university was based on letters, A being the

highest grade and F being the lowest. A multiple regression revealed that achievement and grip strength were related.

In addition, the relationship of age, height, weight with grip strength were investigated and this yielded r's of .118, .326 and .451, respectively. The general conclusion was that grip strength was related to weight and that height's indirect relationship to grip strength was due to the relationship between height and weight.

Yates and Macnab (1977) studied the relationship between a number of variables from the present study. Among the variables studied were age, height, weight and grip strength. On three occasions one week apart 28, 10 year old mite hockey players were tested on all variables. Correlations in this study were much higher than in previous studies yielding the following results.

TABLE VI

Correlations with Grip Strength in Yates and Macnab (1977)

	Left Hand	Right Hand	α
Height	.56	.53	.01
Weight	.62	.68	.01
Age	.49	.46	.01 and .05

These variables were only several of many and the purpose of Yates and Macnab's study was to validate a battery of hockey skill tests rather than to look at the relationships presented in Table VI.

Jones (1946) looked at skeletal maturing and the relationship

to strength in children from the ages of 11 to 17.5 years. Much data were collected on different strength measures. Grip strength curves demonstrated a sudden upward inflection at the age of 13 or what was also termed the onset of the pubertal growth spurt. When early, average and late maturers were compared on grip strength, the early maturers were found to be superior to both the average and late maturers and this trend was consistent from year to year. The difference between the early and late maturers was significant at the .01 level. It was also noted that the early maturers were heavier and taller than late maturers at all ages. During the growth spurt, the growth of the limbs of the body comes first and strength lags a little behind, however, Jones notes that this lag was not as readily noticed in the early maturers. Jones also stated:

> "During several years in adolescence, the late maturing individual is so slow in realizing his physical potentialities that he tends to be handicapped in athletic competition and in status-relationship with others of the same age."

The data from this study and the following two studies are presented in Table VII.

Montpetit and Montoye (1966) investigated the grip strength of Saginaw school children to compare them with children from the same town that were tested in 1899. The original study from 1899 had a total of 1,507 subjects from the ages of 10 - 18. In the latter study 485 boys and 423 girls were studied, their ages varying from 8 to 17. The means of the boys' grip strength from the ages of 8 to 11 are presented in Table VII. Two trials were given with each hand as the

children squeezed a Collin elliptical dynamometer. Height and weight were measured in all subjects. The 1963-64 population was superior to the 1899 group at all ages in both sexes after the age of 13. All data were descriptive, however, and significance tests were not computed. In looking at height and weight it was discovered that the 1963-64 population was taller and heavier than the population of 1899. Correlational analyses revealed a relationship between weight that grew from the ages of 8 to 11 and the reverse was found with height when both of these variables were correlated to grip strength. This was evidenced by partial correlations which showed a decreasing relationship with height from .34 to .00 and an increasing relationship with weight from -.17 to .43. Zero-order correlations with height varied from .33 to .17 and with weight from .15 to .74 at age 11 and back down to .56 at age 16.

Howell, et al. (1967) investigated the status of muscular strength in approximately 36 boys and 39 girls at each age level from the ages of 7 to 15 years to look at the difference between sexes, provide percentile norms of strength and to look at the development of the relationship between weight, height and strength from year to year. A random sample from the Edmonton Public School Board System was subjected to a variety of strength tests. These included: left and right sides for grip strength, elbow flexion, elbow extension, knee extension as well as a back and a leg lift test. Test-retest reliability coefficients were computed and zero-order correlations were calculated permitting the investigation of the relationship between height and weight and the different strength measures.

Test-retest reliability coefficients for grip strength ranged from .73 to .97 throughout the study. Some subjects were given a complete retest and the reliability coefficients increased, narrowing the range to four from .91 to .95. Zero-order correlation coefficients revealed that grip strength varied in its relationship to height and weight over the eight year span of the study. Weight correlated from .39 to .42 for the left and right hand, respectively, at age seven to .49 and .68 at age 15. Height on the other hand went from .54 and .59 at age seven to .40 and .51 at age 15. In general, the correlations with height varied greatly, but showed a definite decrease, going as low as .03 and .07 at age 14 whereas the correlations with weight showed a consistent trend towards greater correlations from year to year.

HOCKEY SKILLS TESTS

Many skills tests have been devised for the purpose of evaluating the ability of hockey players and Larivière (1974) points out that this dates back as far as 1935. Unfortunately, some of these measure only one test (Sabasteanski, 1949; Tower, 1959; Doroschuk and Marcotte, 1965) and others are batteries of tests but seldom have there been attempts to validate these tests as performance predictors (Hansen, 1970; Brown, 1935, Percival, 1956).

Merrifield and Walford (1969) attempted to validate a hockey skills test battery which included a forward and backward speed skating test (each being 120 feet in length), an agility test, a puck carry test and a shooting and passing test. All the tests were scored with

TABLE VII

Data From Comparative Grip Strength Studies

Study	Age	N	Grip Strength Left	Grip Strength Right	Height (cm)	Weight (kg)
Oakland	8	--	--	--	--	--
Edmonton	8	43	14.2	14.9	129.8	28.0
Saginaw	8	22	14.4 ± 3.1*		129.4 ± 5.2[1]	29.6 ± 6.8
Oakland	9	--	--	--	--	--
Edmonton	9	45	16.5	17.1	136.9	31.1
Saginaw	9	37	15.6 ± 2.9[1]		135.7 ± 5.9	33.0 ± 8.5
Oakland	10	--	--	--	--	--
Edmonton	10	46	18.4		141.4	35.4
Saginaw	10	53	17.4 ± 3.0		138.7 ± 6.8	33.8 ± 5.2[1]
Oakland	11	65	23.5 ± 3.93	25.1 ± 4.29	--	--
Edmonton	11	43	18.7	19.6	146.2	39.4
Saginaw	11	56	19.8 ± 4.6		143.3 ± 2.4	38.4 ± 8.3

* The better score of either hand was used.

[1] Standard deviations

a stopwatch except in the case of the passing and shooting test in which subjects were evaluated by awarding them a point for every target hit. A total of 15 subjects were rated according to their hockey ability which, in the author's and coach's opinions, varied from experienced to inexperienced. This rating was used to calculate the validity of the tests. Reliability was calculated by the test-retest procedure. In both the reliability and validity analyses the Spearman rho formula was used.

The reliabilities of the skating tests were reasonable yielding an r = .74 in the forward speed skate, .80 in the backward speed skate, .93 in the puck carry and .94 in the agility test. The reliabilities of the other two tests were low and this was judged to be due to the fact that only two trials were permitted.

The validity coefficients of the tests ranged from .75 in the backward speed skate to .96 in the puck carry. Backward skating correlated well with the agility test yielding an r of .91. Although the validity test yielded relatively high coefficients, an inherent limitation exists in the study. The sample studied was very small, but nevertheless heterogenous in nature with respect to abilities in the sport of ice hockey and this could very likely have made the coach's rating a very simple task. In addition, this rating probably coincided quite well with the scores the subjects achieved on the skills tests, therefore, results from the study must be taken with caution.

In a subsequent study (1971) the same authors investigated the reliability and validity of the same skating tests on young boys 8 to 11 years of age. The same procedures were followed in this study.

All 94 subjects were Pee Wee hockey players and an approximately even number of boys were tested at each age level. In all the tests the subjects were given two trials, the best being used for reliability and validity purposes.

The reliability of the tests ranged from .55 to .97 in the different tests at different age levels. The tests generally yielded good reliability coefficients in all tests at all age levels.

The validity coefficients that resulted are presented in Table VIII.

TABLE VIII

Validity Coefficients of Different Skills Tests

Age (years)	Forward Skating	Backward Skating	Agility Test	Puck Carry
8	.69	.64	.46	.77
9	.69	.70	.83	.70
10	.77	.64	.73	.87
11	.64	.64	.90	.83

Times were found to decrease with age, the greatest change being from 8 to 9 years and the smallest from 9 to 10 years. The backward skating test, the agility test and the puck carry test were all deemed valid, the latter of the three being the most important. The puck carry test was suggested as the one most closely measuring the skill level of the players.

Hansen (1970) conducted a pilot study on a battery of ice

hockey skill tests. A total of 16 tests were administered to 173 Mosquito, Peewee, Bantam and Junior A players. Of all these tests, only eight were recommended by Hansen, these being the Hansen's agility test, Marcotte's modified puck control test and 60, 90, and 120' speed tests.

Results indicated high intercorrelations between some of the tests. For example, the 90 feet forward speed skate had a correlation coefficient of .81 with 120 feet speed skate. The reasonable reliability of these tests was evidenced by a correlation of .71. The validity coefficient based on a subjective ranking by the coaches was .58 for the 90 feet and 120 feet speed skate.

The same pattern followed with the backward skating test, the 90 feet and 120 feet tests predicting each other quite well. In addition, the 120 foot test predicted the agility and puck control tests qite well. The reliability coefficients calculated for the 90 feet and 120 feet backward skating were .79 and .84 respectively.

The Hansen's puck control test tended to have lower correlations with other tests but predicted both forward and backward skating quite well and was related to other puck control tests. Furthermore, it correlated poorly to agility which would seem to indicate that it is measuring a component of skill that is not measured in the other tests. Reliability was higher (.74) with junior players than with bantams (.48) and peewee (.66) players and a validity coefficient of .51 was found.

The agility test also predicted both forward and backward skating and yielded a reliability coefficient of .58 with the Juniors

and .48 with the bantams. When the test was used with another group of 28 hockey players a reliability coefficient of .87 was found. The validity coefficient for this test was .58.

The Marcotte's modified puck control test obtained a reliability coefficient of .74 and a validity coefficient of .63. It should be noted that many of the data were not reported and for this reason some of the correlation coefficients are not presented in the review.

Jobin (1973) conducted a study to establish the validity of the battery of skills tests used in the present study (excluding Macnab and Gill's backward agility test). A multiple regression analysis revealed an MR of .44 explaining only 19% of the variance. His sample was very small and homogeneous, however, including only 14 hockey players and this could definitely affect the regression analysis.

Yates and Macnab (1977) attempted to evaluate the predictive powers of the same battery of skills tests as Jobin including Macnab and Gill's backward agility test. A multiple regression was performed on the collected data and the coach ranked the 28 hockey players involved in the study. Half of the children were members of a control group and half were members of an experimental group.

Correlations between the coach's rating and the different skills tests ranged from .49 with the 60 feet forward speed skate to .90 with the modified Marcotte puck control test. The multiple regression revealed that Marcotte's modified puck control test and the Macnab and Gill backward agility test predicted overall performance the best with an MR of .93 explaining 86% of the variance. The criterion for stopping the analysis was less than a 4% change in the

MR with any of the given variables.

These results are based on subjective evaluation, however, and must be accepted with a certain degree of caution. The difference in skill level between the hockey players may be great enough to make both the subjective rating and the results of the skills tests very similar. The best predictors in this study, however, revealed a consistent pattern with other studies. It seems that in validity studies the backward skating items and puck control items are consistently the best predictors. It is possible that these measures are the best monitors of overall ability in the technical aspects of hockey.

Thibault (1973) looked at the effects of a season of ice hockey on the improvement in ice hockey skills tests in a group of 14 hockey players 8 years of age. Forward and backward speed skates did not improve significantly, however, the forward agility and puck control tests used (which are the same as in the present study) improved significantly. This could have been due partly to learning since it was the first year of exposure of the boys to fairly complex skills.

Retention of Motor Skills

The following studies deal with an important phase of learning called retention. They are directly related to the effect of lay-off periods or periods of no practice on the retention of motor skills.

Meyers (1967) investigated the effects of prolonged lay-offs on the retention of balance coordination learning. A total of 100 subjects, their ages averaging 15.7 years, volunteered for the investigation.

A ladder climb test was employed to test the balance coordination learning of the subjects. The ladder was comprised of staggered rungs on the left and right side and the top rung that was to be grasped was adjusted so that the subject could do so only when the arm was fully extended.

The subjects were randomly assigned to five groups from A to E. The lay-offs in each group varied from 10 minutes to 13 weeks. The subjects were scored by having them do 30 second trials, the highest rung attained before losing their balance being their score. Once the subject had performed 10 trials the scores were summed and the mean was taken as the subject's score.

No difference was found in any of the groups. No skill loss was evidenced even after a 13 week lay-off and it was concluded that balance coordination learning retention was extremely high since the subjects exhibited complete retention after 13 weeks.

Purdy and Lockhart (1962) wanted to answer the following questions in their investigation:

(1) Are skills retained after long periods without any practice?

(2) How much practice is needed to regain proficiency after a lay-off period?

(3) Does skill level have anything to do with the ability of retaining or relearning skills?

(4) Is initial performance in new skills an index of future performance?

To answer these questions 36 females were retested on a battery

of tests that had been used in the previous study. The following five skills were assessed:

(1) nickel toss

(2) ball toss

(3) foot volley

(4) lacrosse (throw and catch)

(5) bingo board (balance test).

The girls were classified as high skilled, low skilled or average on the basis of scores on five sports skills tests and a subjective ranking.

Statistical analysis revealed the following points of interest. First, the skills were retained after approximately a year. Second, relearning to previously attained skill levels was rapid since it only took three days to relearn the skills. Third, the skill groups maintained their relative positions in learning, retention and relearning. The average group retained 98% of the skill while the high and low skilled groups retained 93% and 83% of the skills, respectively. All groups relearned at least to 100% and some even to 120% of the original performances of the tasks and all skills were relearned to the same degree. The investigators claim that there was no practice of the skills during the year lay-off and that the girls knew nothing of the possibility of being retested.

Ryan (1962) in a subsequent study looked at the effect of a lay-off on pursuit rotor tasks and stabilometer performance in 80 volunteers. The subjects were randomly assigned to one of four different lay-off periods, these being 3, 5, 7, and 21 days.

In the pursuit rotor tasks the subjects followed and tried to stay on a moving metal target. The subjects were scored by the number of seconds they could stay on target. A total of 12 one minute trials were given. In the stabilometer test the subjects were required to balance themselves, this being scored according to the number of movements they made, the more movements they made the worse the score and vice versa. A total of 12, 30 second trials were given.

When the different groups were retested on both skills, no significant difference was found between the subjects group in the different lay-off periods. All groups improved significantly (.05 level), however, the stabilometer performance was impaired slightly but insignificantly. In addition, when the two skills were compared the correlation coefficient yielded was .22. The authors, therefore, implied that retention had a different effect on different skills. They also implied that retention was not related to the length of the lay-off period, however, the lay-off period itself was very likely too short to demonstrate forgetting of the skills in question.

Ryan (1965) looked at the effect of extended lay-off times on stabilometer performance in 90 men averaging 30 years of age. The subjects began with a three trial pre-test and had a three day lay-off. The following session they completed 11, 30 second trials and were placed in three groups of 30. One group had a 6 month lay-off, the second a 9 month lay-off and the last had a 12 month lay-off before being retested. Identical instructions were given prior to the retesting session.

All groups had lost a certain amount of proficiency, the first

group retaining 50%, the second 42.2% and the third 19.1% of their skills after the pre-test and post-test scores were compared. Groups one and two were significantly different from group three. The third group retained much less and relearned more slowly taking more trials to regain their initial proficiency level than other groups.

CHAPTER III

METHODS AND PROCEDURES

Sample

Except for one subject, all the participants in this study were from the community of Malmo in Edmonton, Alberta.

During the first year of the study the competitive hockey group included 14 boys 8 years of age as of December 31, 1973. A similar group of boys who were not participants in hockey was used as a control group (Thibault 1973). The competitive group remained unchanged during the second year, however, three subjects dropped out of the control group (Gill 1976).

In the third year a new control group consisting of subjects who played hockey in a more recreational league and of a lower skill level was introduced. One player was added to the competitive group (Yates, unpublished).

The group remained unchanged during the fourth year. One subject from the competitive group dropped out of the study while one player from the control group was transferred to the competitive group since he became a member of the competitive hockey team.

At the end of four years of study there were fifteen subjects in both the competitive and control groups. Data were collected on all measures for the four years with the competitive group. For the hockey control group, however, data exists only for the last two years. Two of the control group subjects were excluded from analysis because of missing data.

The competitive group was considered to be highly skilled and trained since they played an average of 63 games a season. They were Edmonton city finalists in two of the years and Edmonton City champions in the fourth year of the study. In addition, they averaged two practices a week and attended approximately four weeks of hockey school instruction during the summers. They were also involved in activities such as soccer, lacrosse, fastball and power skating.

The hockey control group played an average of 25 games per year and practiced once a week. They were considered to have trained to a much lesser extent than the competitive group during the hockey season.

Both groups were considered highly active and were not considered to be a random sample of the general population. Some of the characteristics of the subjects are presented in Appendix A.

Testing Conditions

Two batteries of tests were included in each year of this study: hockey skill tests and the CAHPER fitness performance items. Grip strength, $P.W.C._{170}$, height and weight were also measured each year.

During the first season the hockey skill tests were conducted on an outdoor rink with temperatures varying from +15 to +25°F. Ice conditions were considered to have varied greatly (Thibault, 1973). For the last three years these tests have been conducted at the ice arena of the University of Alberta.

The C.A.H.P.E.R. fitness performance items, height and weight were conducted in the main gymnasium of the University of Alberta during the first three years. During the fourth year, however, main

gymnasium renovations and time limitations forced scheduling of the events in the dance and gymnastics gymnasia. The 50 yard dash and the 300 yard run were run in the corridor adjacent to the men's and women's locker rooms. In this manner, it was hoped that variability of conditions could be kept to a minimum.

The P.W.C.$_{170}$ and grip strength tests were conducted in the physiology laboratories at the University of Alberta in the first year and at the Malmo community centre for the last three years of the study.

Pre and post season measures were taken each year for the hockey skills tests. Grip strength, P.W.C.$_{170}$, height, weight and the C.A.H.P.E.R. fitness performance items were measured pre and post season during the first year but only post season in the following three years. Table I depicts each measure and the approximate date of measurement denoted by month.

Table IX

Data Collection Dates

Test	1973-74		1974-75		1975-76		1976-77	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Hockey Skills	Dec	Feb	Oct	Feb	Oct	March	Oct	March
C.A.H.P.E.R.	Nov Dec	Apr		Apr		Apr		Apr
PWC$_{170}$ & Grip	Nov Dec	Apr		Apr		Apr		Apr

Diet, external activities and environmental conditions were not controlled at any time during the study. Environmental conditions were

judged to be fairly constant throughout the study except in the previously mentioned case of Thibault's hockey skills testing.

Testing Procedures

P.W.C.$_{170}$

The P.W.C.$_{170}$ test was conducted according to the method of Howell and Macnab (1968). A modified Monark bicycle ergometer with adjustable pedals and seat was used. The seat was adjusted for each subject to suit their leg length and comfort. The bicycle was zeroed and calibrated prior to each testing session according to the method of Howell and Macnab (1968). The calibration constants are recorded in Appendix B.

The subjects pedalled for twelve minutes at sixty revolutions per minute. A pre-calibrated metronome was used to designate the rate of pedalling and the subject was instructed to pedal in time with the metronome. At the fourth and eighth minute of the test the workload was increased so that subjects achieved the desired heart rates at each stage of the test (Howell and Macnab 1968). Three plate electrodes were attached to the subject; one on each side of the subject's chest and one on the right side of the back. Heart rate was recorded with an E.C.G. 500 Sanborn Viso-Cardiette. A resting heart rate and minute by minute heart rates were recorded during the test. A revolution counter was connected to the bicycle to record the exact number of revolutions pedalled by the subject during the test.

Predicted MVO_2

Predicted values of MVO_2 were calculated using a computer program constructed on the basis of the Astrand nomogram. The physical work

capacity values were inserted to get the estimate based on the heart rate versus the work load. A copy of this program is presented in Appendix C.

C.A.H.P.E.R. Fitness Performance Items

The C.A.H.P.E.R. fitness performance items were conducted according to the method of C.A.H.P.E.R. 1966. The performance test consisted of:

(1) 50 yard dash - From a standing or crouched position the subjects ran a 50 yard straight sprint in pairs. On the starter's signal ("Ready, Go") which was the brisk downward motion of his extended arm, the timers started the stop watches and they were stopped when any part of the body crossed the finish line. Both subjects were monitored and times were recorded to the nearest tenth of a second.

(2) 300 yard run - The 300 yard run was conducted using the same criterion and method as the 50 yard dash. The course for this measure consisted of two pylons set 50 yards apart which was circled three times.

(3) Shuttle run - On the starter's signal two subjects lying face down at the starting line ran to a point 30 feet away, picked up a block, returned to the starting line, placed the block behind the starting line, returned and picked up the second block, then sprinted straight through the finish line. Criterion and times were recorded as in the previous two runs. Two trials, with a rest between trials, were given with the best time for each subject being recorded.

(4) Speed sit-ups - To perform the sit-ups subjects laid on a mat with their hands clasped behind their heads and knees bent. A partner held the feet down on the mat while the subject performed his sit-ups.

On the starter's signal "Ready, Go", subjects began to perform the sit-ups touching their elbows to their knees and returning to a prone position on the mat. The subjects were asked to do as many of these sit-ups as they could in one minute. At the end of sixty seconds subjects were instructed to stop and their scores were recorded to the nearest complete execution of a sit-up.

(5) Flexed arm hang - The subjects grasped a horizontal bar with palms towards the face. Help was given to each subject to lift him up to the bar. The subjects were instructed to keep their arms flexed so that the bar was at eye level at all times. A stop watch was used to record, to the nearest second, the moment at which the subject could no longer hold this position. Only one trial was permitted and the test terminated when the subjects could no longer keep the bar at eye level.

(6) Standing broad jump - The subjects began with their feet slightly apart and with their toes behind a starting line on the floor. Then, by bending their knees and ankles while swinging their arms, the subjects jumped as far as they could. Scorers marked the distance jumped from the starting line to the back of the nearest heel. The subjects were instructed to take off with their knees bent at an angle of 30 to 45 degrees. Two trials were given and the furthest jump was recorded to the nearest inch.

Motivation by encouragement was given to all subjects in all events. Instructions on how to perform all the tests were given prior to the actual testing. All subjects were tested in one or two consecutive days or evenings. Subjects wore gym shoes for all events and most of the subjects wore gym equipment. All measurements were made using "Hanhart" stop watches and a cloth type 50 meter measuring tape.

Height and Weight

In conjunction with the C.A.H.P.E.R. fitness performance items, height and weight were recorded on a medico-detecto scale. Height was recorded to the nearest inch and converted to the nearest tenth of a centimeter and weight was recorded to the nearest .5 of a pound. Shoes were removed for both of these measurements.

Strength Measurements

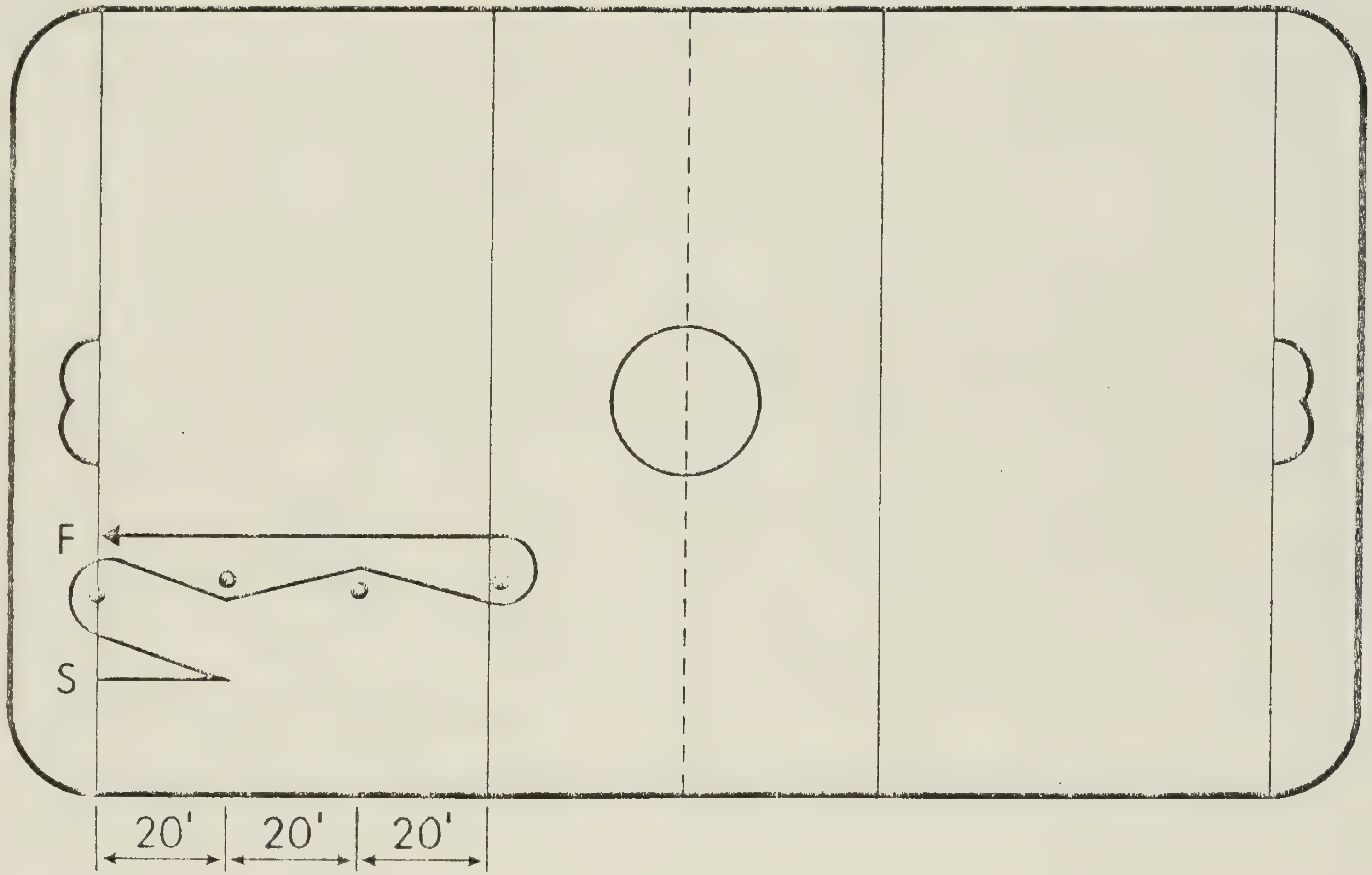
In each year of the study, grip strength was measured just prior to the physical work capacity test with a Stoelting hand grip dynamometer. The subject adjusted the handle to a comfortable position, and the tester demonstrated the technique to be used. The subject was instructed to begin with the dynamometer at shoulder height with the arm extended out from the body then squeezed the dynamometer as hard as possible bringing his arm down to his side. Each subject was given two trials with each hand and the best score for each hand recorded to the nearest .5 kilogram.

Hockey Skill Tests

Hockey skill test measurements were made during the pre-season and post-season of each year by the method of Hansen (1970). In addition, backward agility test was administered in the post season of the second year and the pre and post season of the last two years. Prior to each test, instructions were given by explaining and demonstrating the procedure of each test. If a subject failed to properly execute any particular test he was sent to the back of the line to repeat the test.

Figure 1*

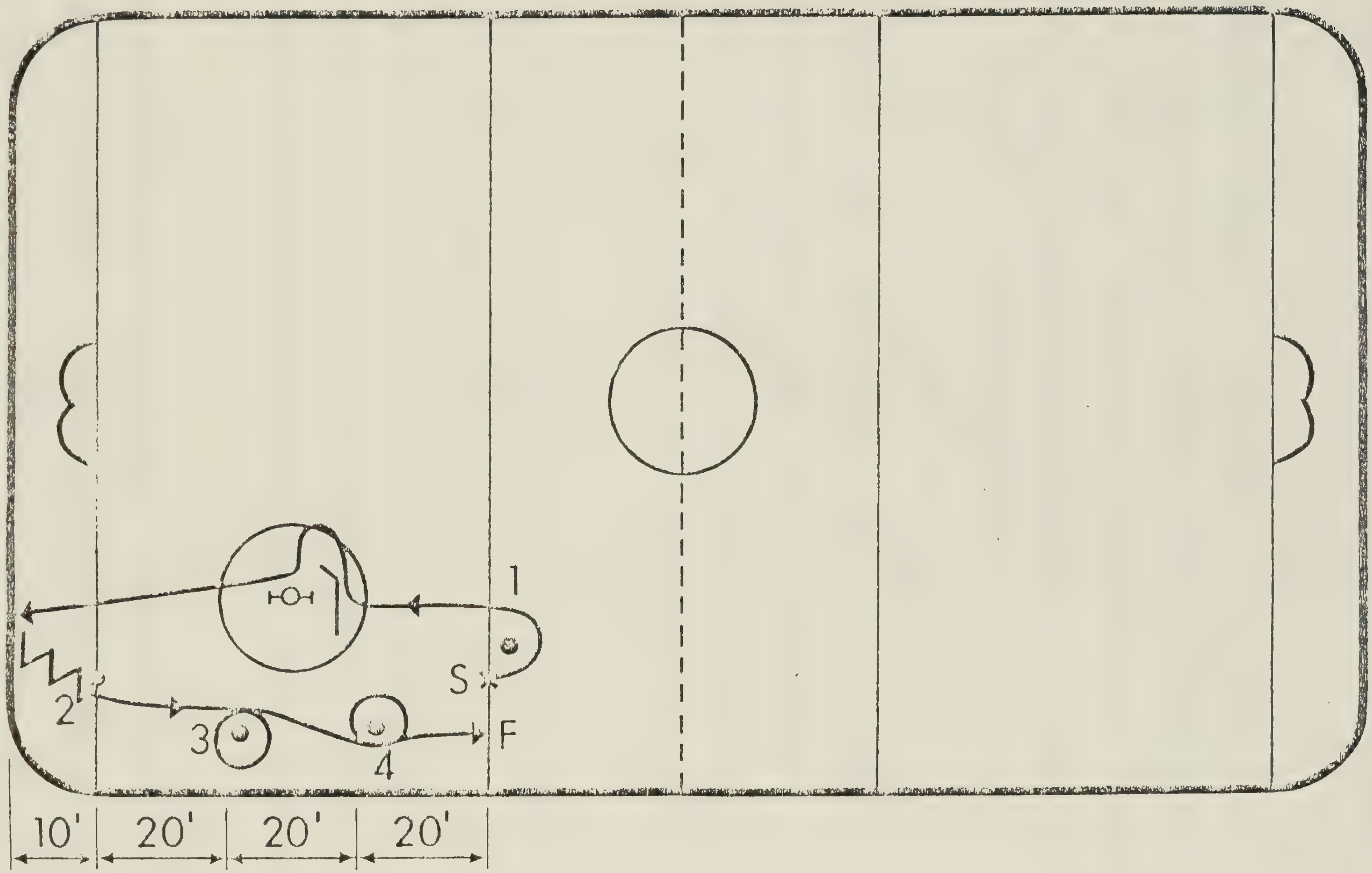
Diagramatic Representation of Modifed Marcotte's Puck Control Test



* Legend of Figures in Appendix D

Figure 2*

Diagramatic Representation of Hansen's Puck Control Test



* Legend of Figures in Appendix D

Measurement procedures and criterion were analogous to the C.A.H.P.E.R. running item. An explanation of each test with figures, where necessary, follows.

(1) Forward Speed Skate (60', 90', 120') - The subject had a running start from the end boards and skated as fast as possible from the goal line past three cones which were set linearly at 60, 90 and 120 feet. Subjects skated in pairs, the furthest away from the timers being a motivator. The two players then went to the back of the two lines alternating lines as they did so and the second subject was timed during the second trial. Timers were located at each pylon.

(2) Backward Speed Skate (60', 90', 120') - The procedure in this test was exactly the same, however, the players started from a standing position at the goal line and skated backwards on the sprint past the cones.

(3) Marcotte's Modified Puck Control Test - Figure 3-1 depicts the course that subjects followed on this test. The subject started at the goal crease with a puck on his stick and both skates on the line. He then skated out as far as the first cone, changed directions, skated back, weaved through the cones on the ice and sprinted back to the finish line.

(4) Hansen's Modified Puck Control Test - Figure 3-2 depicts the course the subjects travelled to complete this test. From a standing start, the subject kicked a puck ahead to his stick from the blue line and skated around the first cone in a counter-clockwise direction. He then skated towards the stick and jumped over it while handling the puck and proceeded to the boards. From there he skated backwards to the

next cone, turned around, skated to the third cone and circle it entirely in a clockwise or counter-clockwise direction. Following this, he skated to the fourth cone and circled it in the opposite direction, then skated past the blue line.

(5) Forward agility test - Figure 3 presents a diagrammatic representation of the course for this test. From a standing position with his back to the first cone, the subject skated backwards to the cone, reversed directions, jumped over the blue line, ran past the hockey stick, went around the first cone, circled the next and skated back to the finish.

(6) Backward agility test - Figure 4 shows the course to be followed during this test. From a standing position in between the cones, the subject skated backwards weaving through the cones to the finish line 75 feet away.

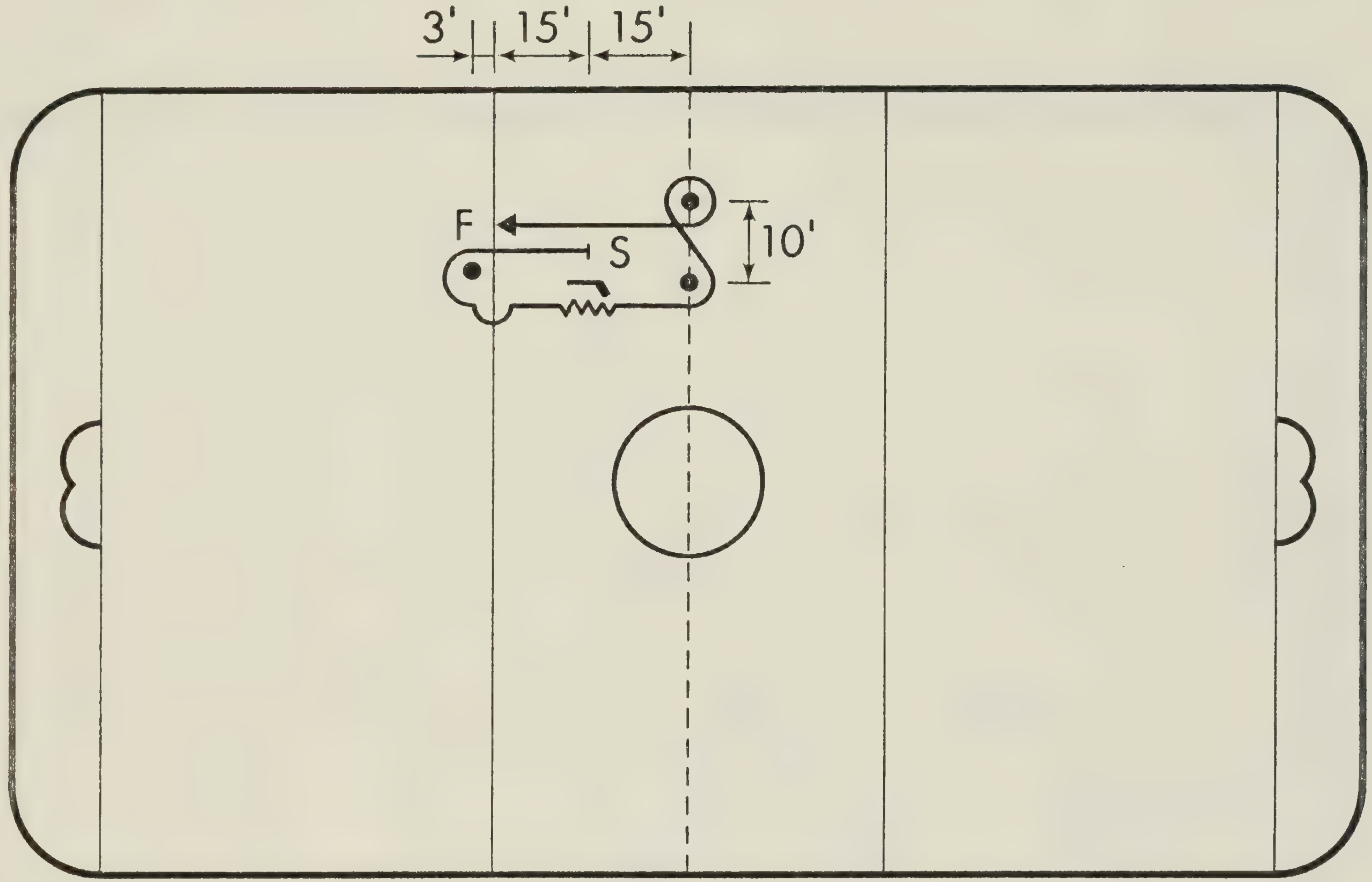
Statistical Procedures

Means and standard deviations were calculated for each test and graphs were used to present the longitudinal development of each measure. No data had been collected for two subjects in the competitive group during the first two years. Since these two subjects would be involved in future years it was determined that estimates of data for the first two years based upon the relation to the values they obtained in the last two years would be advantageous. These two subjects are indicated by asteriks.

The estimation procedure is explained on the next page.

Figure 3*

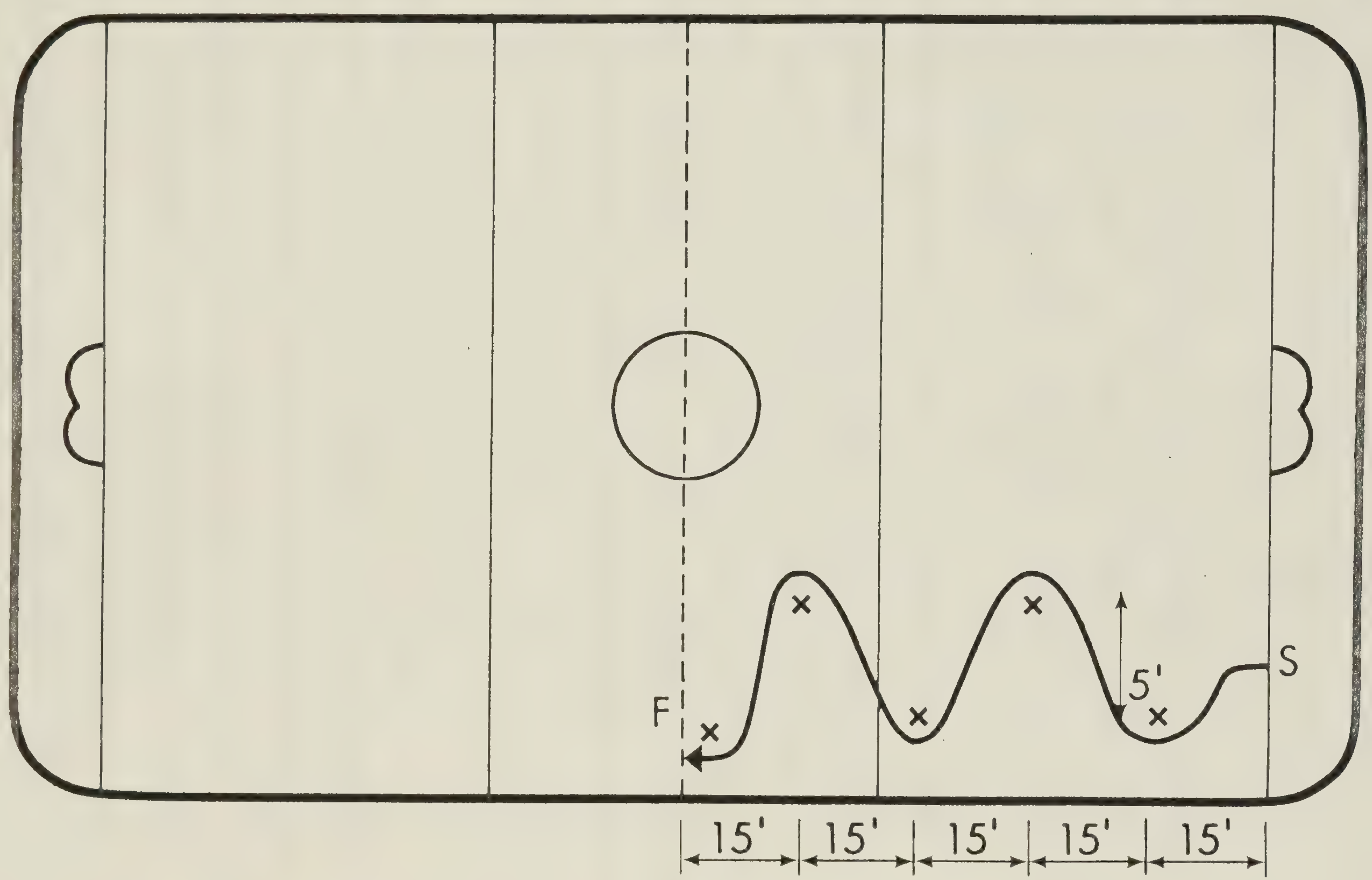
Diagramatic Representation of Agility Test



* Legend of Figures in Appendix D

Figure 4

Diagramatic Representation of Macnab and Gill's Backward Agility Skate Test



E.g.

	1	2	3	4
Subject's Scores	10.2	10.1	8.9	10.5
Group Mean	10.0	10.2	9.0	11.0

Therefore, the subject was .5 below the mean across the board and .5 ÷ 4 = .1 below the mean. Thus, in all other scores of the previous two years for that measure his score was adjusted to one tenth below the group mean.

During the backward agility test, a procedural error when measuring the length of the course caused a gross overestimation of times in the case of eleven subjects in the competitive group. Five of the subjects were retested but because of time limitations and ice removal, it was impossible to retest six of the subjects. Rather than jeopardize the analysis of the data in this test, a similar estimation of their times was made.

Testing Procedures

In each year of testing all procedures were kept constant in several ways. The study was initiated by Dr. R. Macnab in 1973 and he led and supervised all testing sessions from year to year. All of the secondary investigators collaborated and helped each other in testing sessions from year to year. Methods and procedures were written and were consistent in each year of the study.

CHAPTER IV

RESULTS AND DISCUSSION

All raw scores of the present study are reported in Appendix D, and E. All raw scores of the comparative studies are presented in Tables I, IV, V, and VII. Each variable studied has been graphed and will be presented in the appropriate section of the discussion. The experimental group is indicated by a dotted line on all graphs.

Body Weight

It can be seen from the graph in Figure 5 that the body weight of all study groups increases yearly except in the case of the Winnipeg children (Cumming and Cumming, 1963), however, the latter is a cross-sectional sample and this definitely could have had an effect on all results yielded from that study. The California (Adams, et al., 1961) sample placed very high relative to the other groups. The children from the present study are similar to other Canadian data (Howell and Macnab, 1967), Swedish (Adams, et al., 1961) children and the control group which suggests an apparently normal development with respect to this measure.

Height

Figure 6 depicts the height of the children from the same studies except for that of Howell and Macnab (1967). In the first year of the study the experimental group is slightly taller than the rest, but in

Figure 5

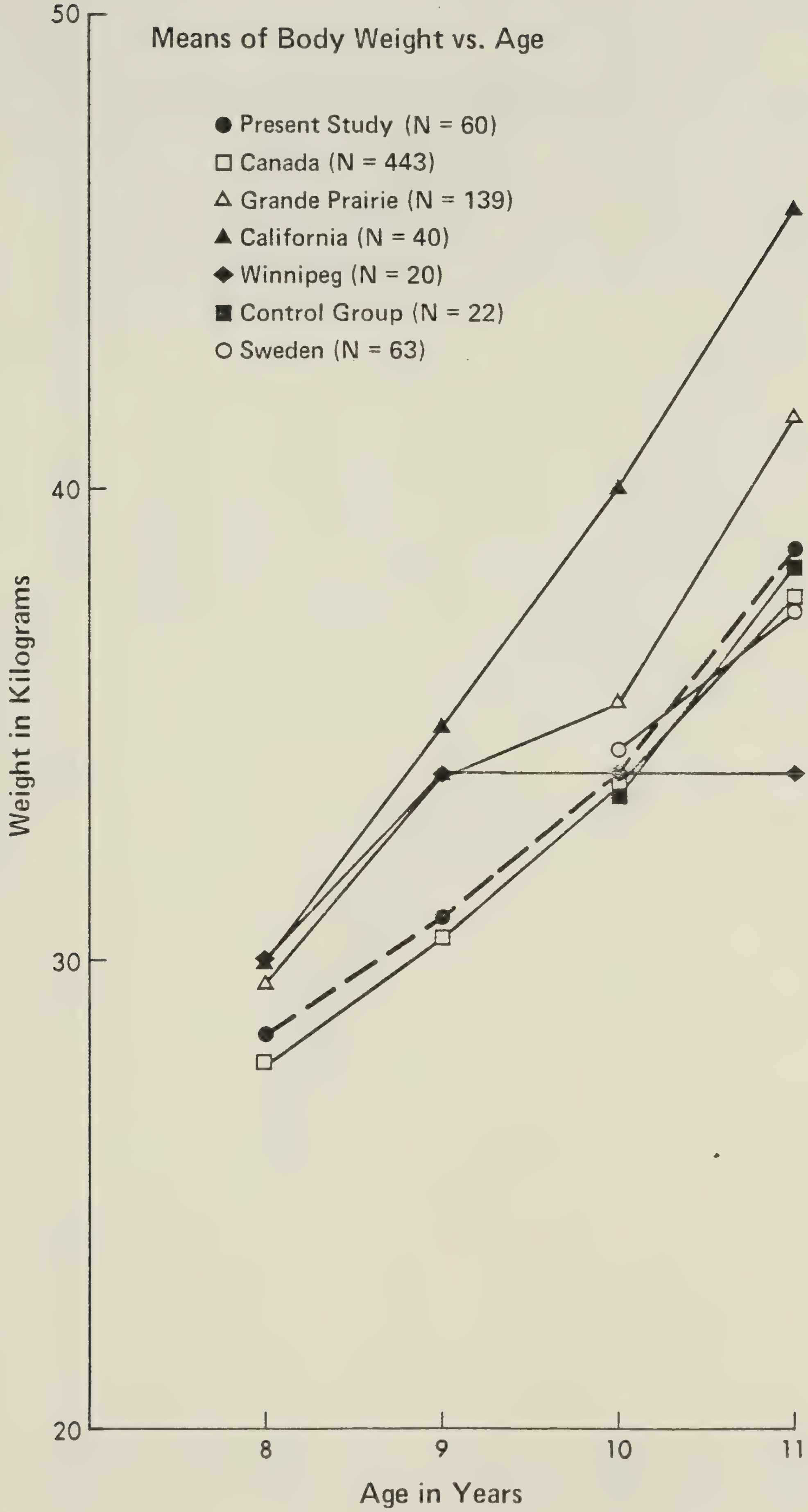
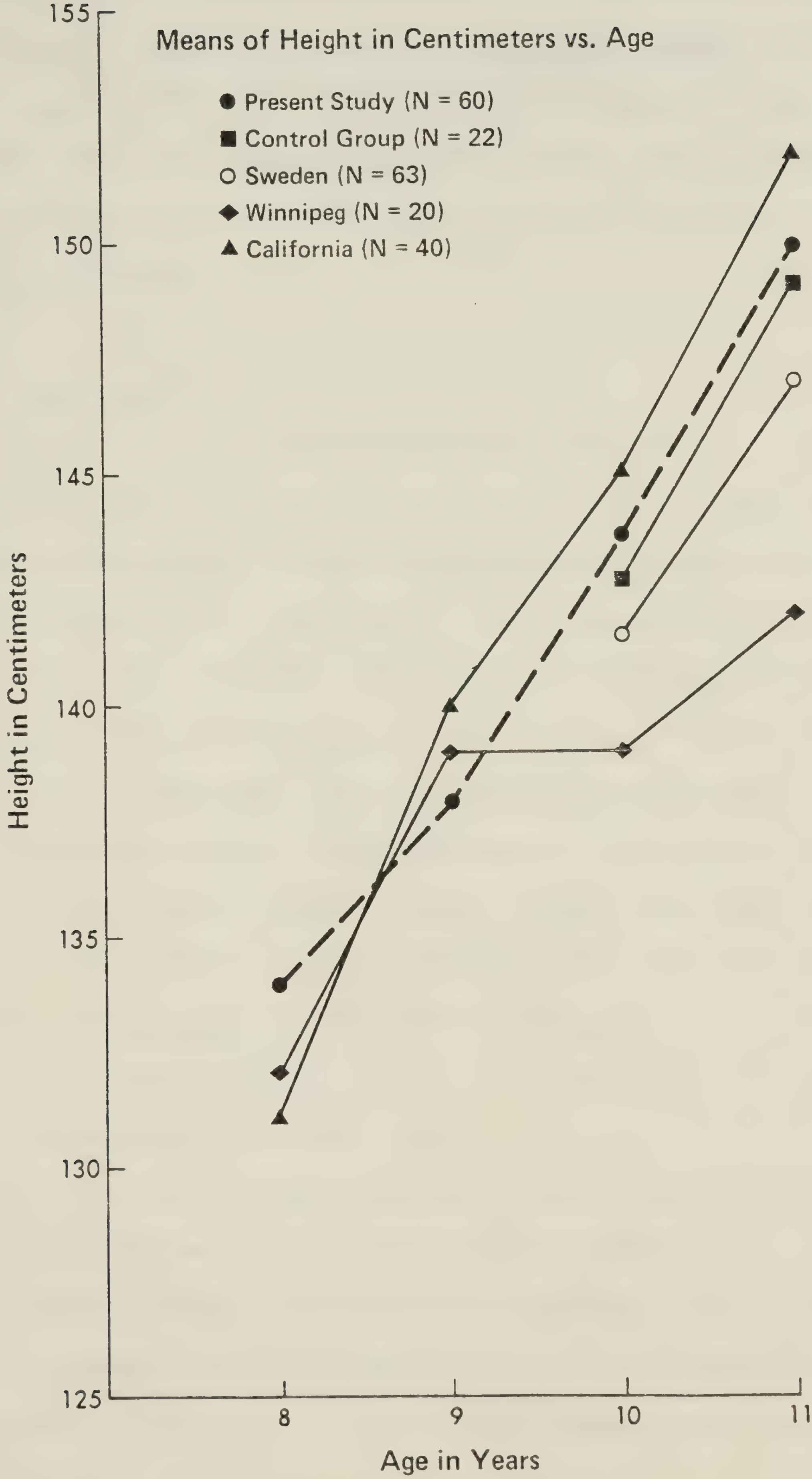

50
40
30
20
Means of Body Weight vs. Age
Present Study (N = 60)
Canada (N = 443)
Grande Prairie (N = 139)
California (N = 40)
Winnipeg (N = 20)
Control Group (N = 22)
Sweden (N = 63)
Weight in Kilograms
8
9
10
11
Age in Years

Figure 6

Means of Height in Centimeters vs. Age



subsequent years the experimental group is overtaken by the Californian (Adams, et al., 1961) sample and the Swedish (Adams, et al., 1961) and control groups closely approximate the values of the experimental group. Traditional lines seem to be followed here, however, the experimental group more closely approaches the values of the Californian children (Adams, et al., 1961).

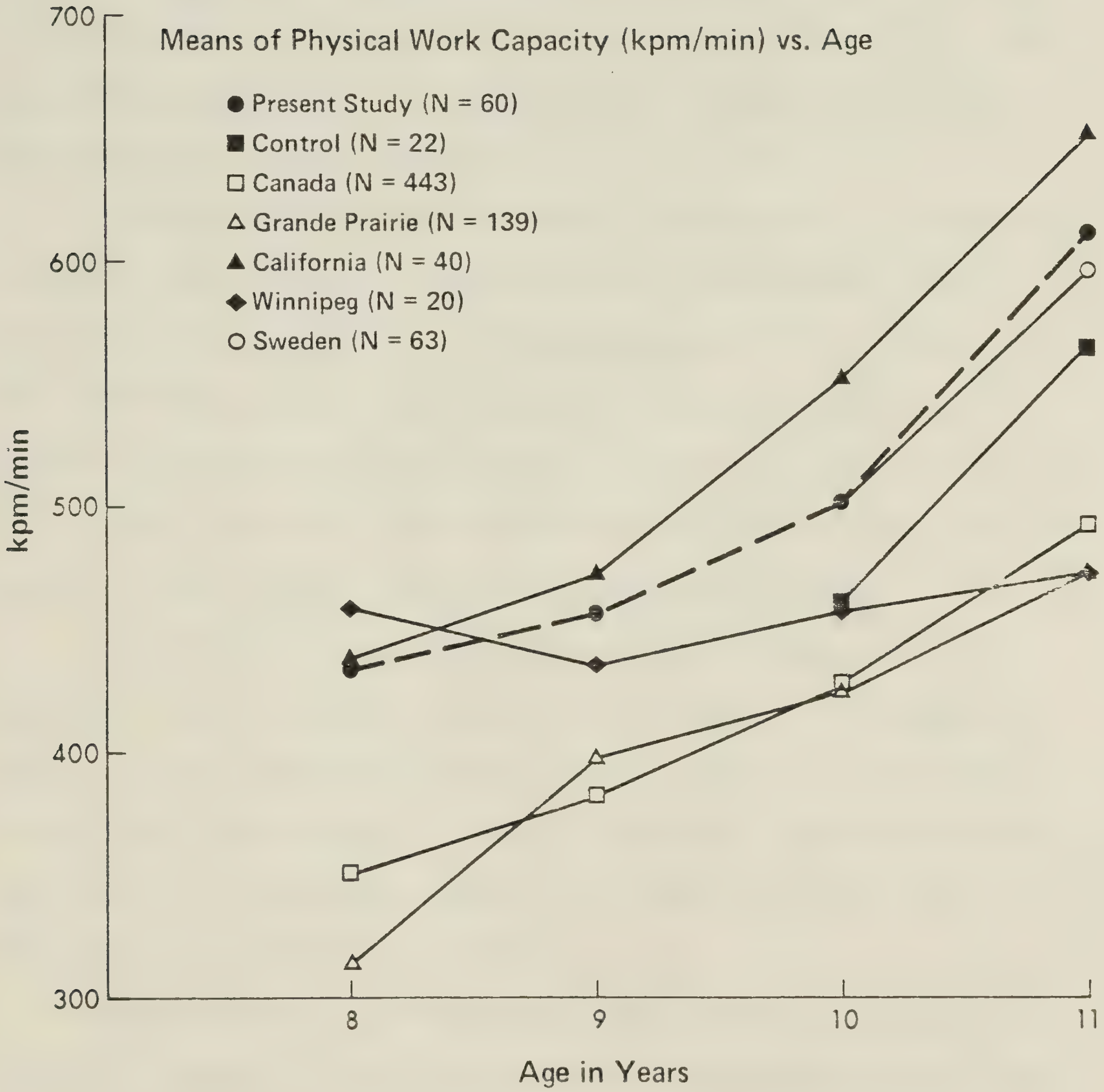
Physical Work Capacity

Figure 7 illustrates the development of physical work capacity in the experimental group (dotted line) and the control group along with other available data. When body weight is not factored out, the Californian children (Adams, et al., 1961) surpass those of the present study. The data of the others (Cumming and Cumming, 1963; Adams, et al., 1961; Dunkley, et al., 1976; Howell and Macnab, 1967) and the control group remain lower than the experimental group.

The general picture furnished by Figure 7 illustrates inferiority relative to the Californian sample (Adams, et al., 1961), superiority over the Winnipeg sample (Cumming and Cumming, 1963), equality with the Swedish (Adams, et al., 1961) children and superiority over the Grande Prairie (Dunkley, et al., 1976), the control group and the Canadian norms (Howell and Macnab, 1967).

It is difficult to make any conclusions regarding the PWC_{170} values of the experimental group when they are compared to the California, Swedish, Winnipeg and Grande Prairie children. All of these previously mentioned groups are made up of cross-sectional and non-random samples rather than a true longitudinal sample and it would

Figure 7


700
Means of Physical Work Capacity (kpm/min) vs. Age
Present Study (N = 60)
Control (N = 22)
Canada (N = 443)
Grande Prairie (N = 139)
California (N = 40)
Winnipeg (N = 20)
Sweden (N = 63)
600
500
400
300
kpm/min
8
9
10
11
Age in Years

therefore be spurious to claim that these groups are normal.

In the case of the Canadian norms, however, a much larger random sample was chosen for study across the entire country and this group can more readily be accepted as a representative sample of Canada.

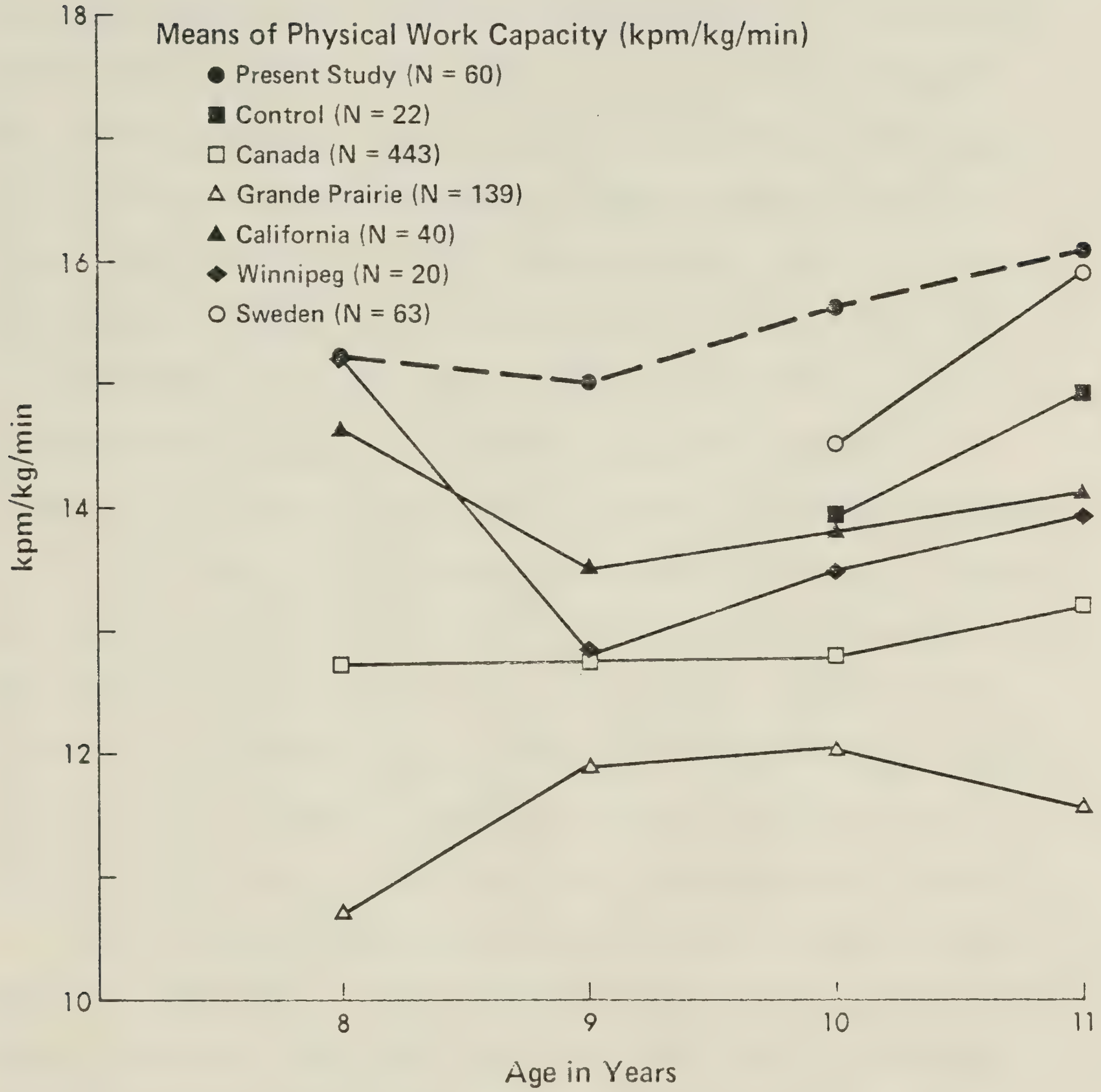
Relative to the Canadian norms, the experimental and control groups of the present study show a definite superiority. With respect to sedentary individuals, it would seem that hockey players exhibit a superior energy delivery system.

To develop this point even further, however, it is perhaps more precise to express physical work capacity in terms of body weight. When this is done, a totally different perspective arises (Figure 8). The experimental group is definitely superior to all other groups except the Winnipeg children at age 8. In addition, it is interesting to note that the control group itself is only surpassed by the Swedish children (Adams, et al., 1961) and the experimental group.

The pattern of progression shown in both Figures 7 and 8 are similar in all the studies, however, the magnitude of the change in the case of the experimental group is much greater since they begin at an already superior level. It is of interest to speculate reasons for which this superiority exists in the experimental group and why it persists over the four year span.

Many problems arise from the attempt to delineate growth and training. Changes in work capacity may be due to both of these factors, or it could be due to other factors such as heredity (Klissouras, 1972; Weber, et al., 1976) or a change in hormonal actions on the body or a

Figure 8


Means of Physical Work Capacity (kpm/kg/min)
Present Study (N = 60)
Control (N = 22)
Canada (N = 443)
Grande Prairie (N = 139)
California (N = 40)
Winnipeg (N = 20)
Sweden (N = 63)
kpm/kg/min
18
16
14
12
10
8
9
10
11
Age in Years

combination of these factors.

Growth can be said to be factored out to a certain extent when a control group is used and in this instance from looking at Figure 8 playing hockey in addition to high activity levels during the summer can be postulated to be responsible for at least part of this change. Still, the experimental group is an elite group and was selected to play on the experimental group's team at an early age. With this in mind, it would have been interesting to compare these children as early as the age of five or six. Perhaps heredity would have been evidenced as a more important factor or perhaps a training effect could have more easily been demonstrated. On the one hand, training studies (Cumming, et al., 1967; Cunningham, 1976; Massicotte and Macnab, 1974; Seliger, et al., 1974; Sprynarova, 1974; Cunningham and Eynon, 1973; Daniels and Oldridge, 1971; Ekblom, 1969) are in disagreement concerning the effects of training on the working capacity of children and on the other hand, some investigators (Astrand, 1963; Klissouras, 1973; Weber, et al., 1976; Klissouras, 1971) have offered the possibility of a genetic ceiling and that training may possibly have a potentiating or maximizing effect on cardiovascular fitness.

Also, it is difficult to relate ice hockey to MVO_2 or aerobic power and vice versa. Studies (Seliger, 1968; Seliger, et al., 1972; Houston and Green, 1973; Nagai and Ogawa, 1972; Green and Houston, 1975; Houston and Green, 1976; Hedberg and Wilson, 1976) have shown that a high aerobic component is not necessarily characteristic of a hockey player. When compared to other endurance athletes (Nagai and Ogawa, 1972) hockey players do not have as high an MVO_2. It is per-

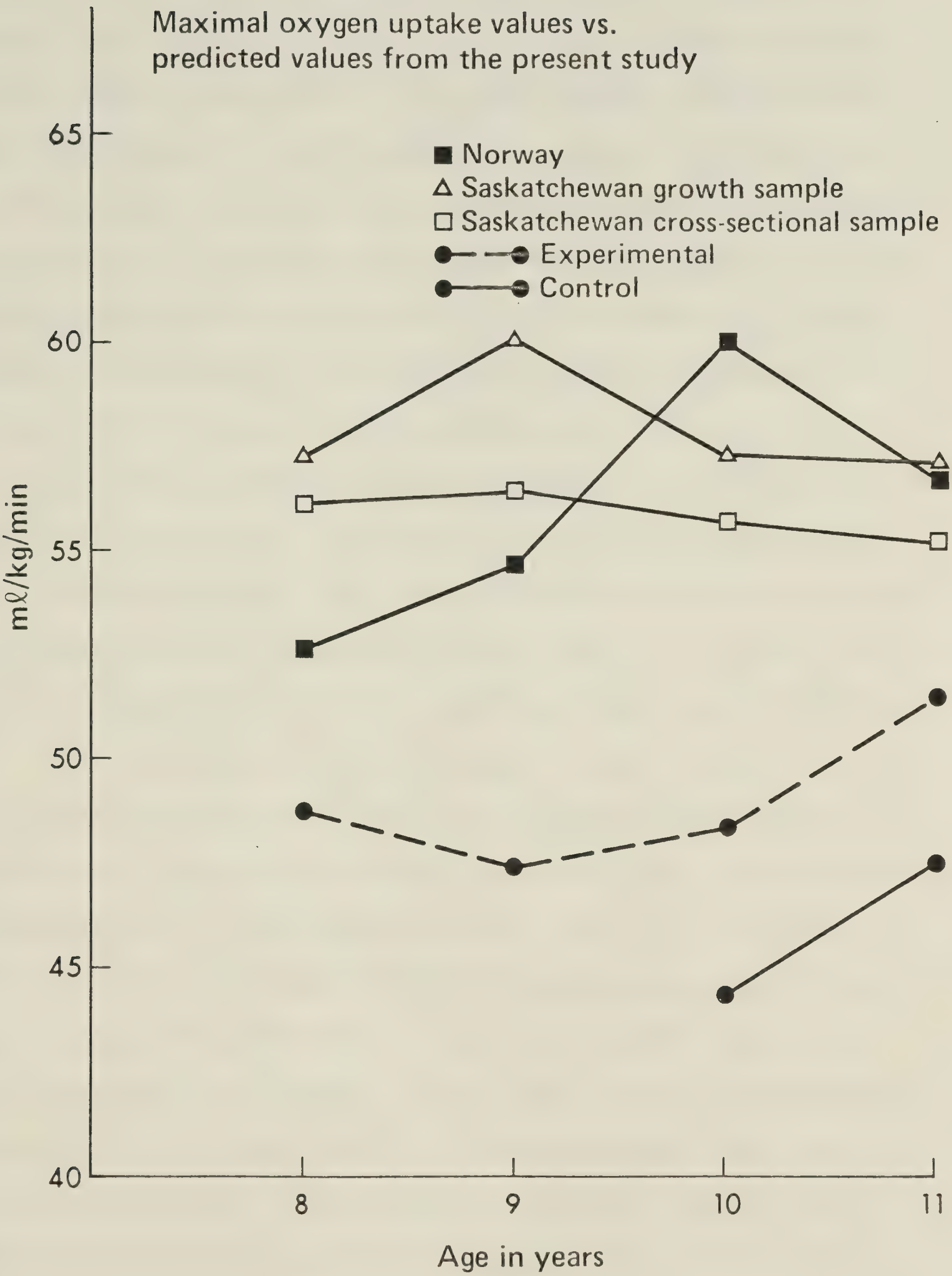
haps more realistic to assume that there is a considerable participation of the anaerobic and aerobic energy systems when playing the sport of ice hockey.

Predicted MVO_2

Data on MVO_2 has been recorded in children over the years (Andersen, 1976; Mirwald, 1973; Shephard, 1966) and these results give us a good general picture of the cardiovascular health of different populations as measured by direct and predicted MVO_2 tests. In one study (Shephard, 1966), however, procedural discrepancies make it impossible to use the data for comparative purposes. For example, the data from Winnipeg (Cumming and Cumming, 1963) used in Figure 7 and 8 is at an inferior level relative to the experimental group of the present study, however, becomes superior to the latter after a predicted MVO_2 was assessed to the Winnipeg group by Shephard (1966). The reason for this increase is that Shephard (1966) added 7% to the scores of those people who had been tested on a bicycle ergometer and 8% to the score of unfit individuals since he was using the Astrand-Rhyming nomogram (1954) and this latter method of estimating MVO_2 has a tendency to underestimate in the case of unfit individuals (Astrand, 1967). Shephard (1966) has done this with data from other countries that were used in the present study (Adams, et al., 1961) in an attempt to equate all subjects from all studies for national groupings and international comparisons. These methods, unfortunately, are inaccurate and unapplicable to the purposes of the present study.

Figure 9 is a comparison of MVO_2 in ml/kg/min (Anderson, 1976;

Figure 9



Maximal oxygen uptake values vs.
predicted values from the present study
Norway
Saskatchewan growth sample
Saskatchewan cross-sectional sample
Experimental
Control
mℓ/kg/min
65
60
55
50
45
40
8
9
10
11
Age in years

Mirwald, 1973) with predicted values from the data of the present study. Severe limitations are inherent in the presentation of this figure. Direct and predicted values are virtually different measures since the methods of estimating MVO_2 are completely different procedurally. Several authors (Astand and Rhyming, 1954; Davies, 1968; Wyndham, et al., 1967) have demonstrated both the advantages and the limitations of predictive tests for the estimation of MVO_2. Davies (1968) and Wyndham et al. (1967) have also shown that when using the Astrand-Rhyming nomogram a clear underestimation of MVO_2 tends to arise in unfit individuals whereas an overestimation results in the case of fit individuals. Conversely, Wyndham, et al. (1967) point out that predictive tests that use successive increments in work rate to a heart rate of 170 to 180 beats per minute as in the PWC_{170} test causes an underestimation of the true MVO_2 of most young individuals.

The experimental and control group's inferiority to the Norwegian group in Figure 9 is not so surprising in the light of the limitations of the predictive power of the tests used in the present experiment and the relatively high fitness levels of the Norwegian children. The high scores of the Saskatchewan groups, however, are surprising and the inferiority of our groups to these subjects is even more surprising, however, it is evident that both the subjective evaluation of the fitness levels of the Saskatchewan groups were underestimated and, in addition, the scores of the present groups were likely underestimated (Wyndham, et al., 1967). The reason for the lack of difference between the Norwegian and Saskatchewan children could be due entirely to the different testing procedures when using

a treadmill versus a bicycle as has been pointed out earlier by Glassford and his co-workers (1963).

Much confusion arises when attempts are made to determine the accuracy of predictive tests of MVO_2. Perhaps the most viable point to be made from this section is in relation to the results presented in Figures 7 and 8. The children from the present study demonstrate fitness levels, as measured by the PWC_{170} test, that are much higher than any available data reported in the literature for their age group. In addition, rather than seeing decreases in fitness levels (Bailey, 1973) from year to year, a maintenance or an increase of very high fitness levels is evidenced.

CAHPER Fitness Performance Items

A paucity of studies have been done dealing with research of the CAHPER performance items (Hayden and Yuhasz, 1966; Ellis, et al., 1975; Cumming and Keynes, 1967; Olree, et al., 1965, Falls, et al., 1966; Docherty and Coliss, 1976; Crawford and Mason, 1974; Rothermel, et al., 1968).

Norms have been devised (Hayden and Yuhasz, 1966) and the reliability of the items has been established (Crawford and Mason, 1974; Rothermel, et al., 1968), however, most of the validation work has been in an attempt to relate the CAHPER or AAHPER items to MVO_2 tests (Docherty and Colliss, 1976; Olrec, et al., 1965; Falls, et al., 1965; Cumming and Keynes, 1967) with little success.

On the other hand, Ellis et al. (1975) and Hayden and Yuhasz (1966)

have attempted to look at the development of various CAHPER items longitudinally. In the present study, each item will therefore be discussed individually to look at the development of these parameters rather than its relationship to other measures.

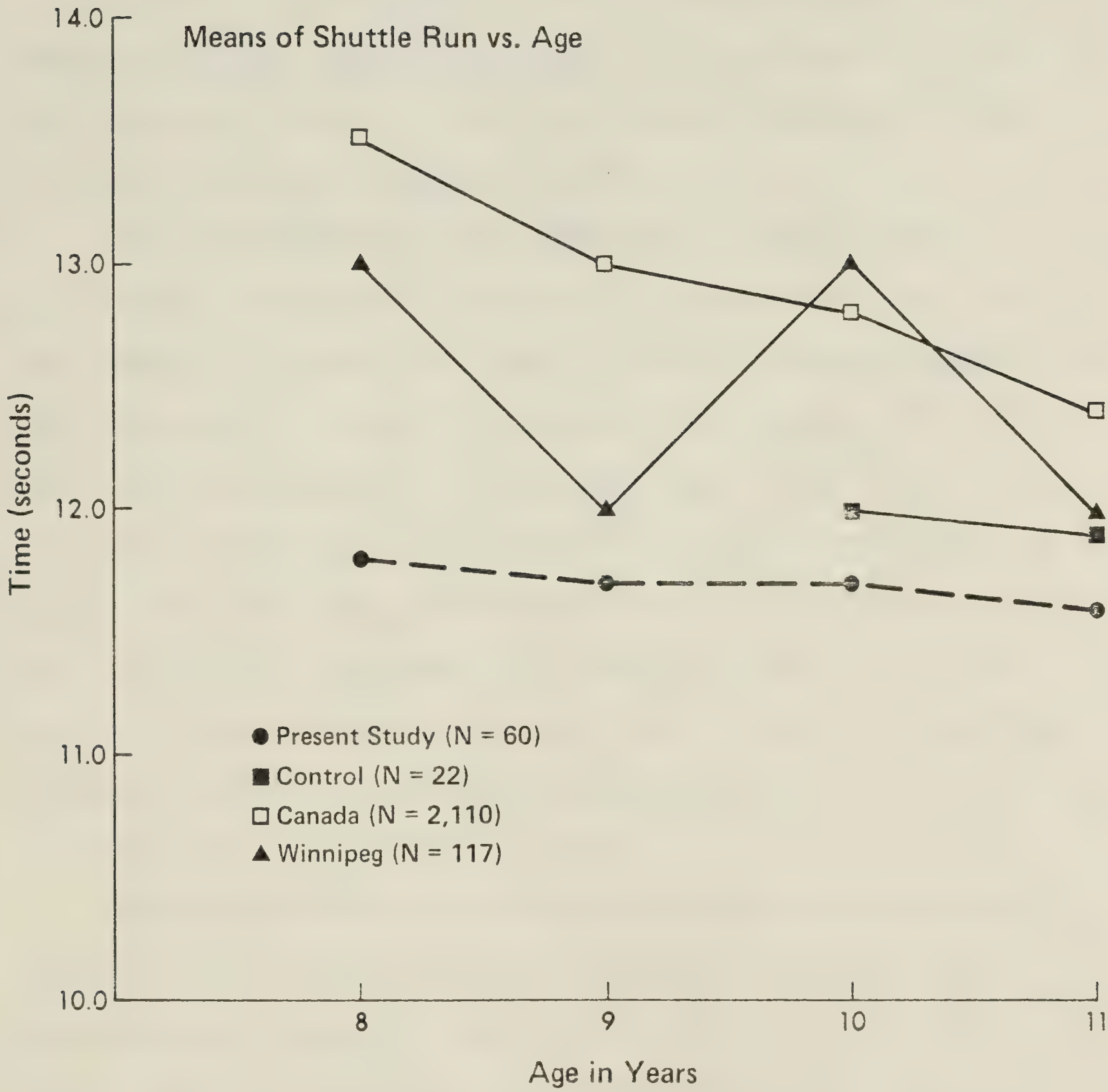
Shuttle Run

The shuttle run results are graphed in Figure 10. The superiority of the experimental group is evidenced once again when the comparison with the control group and other available data (Hayden and Yuhasz, 1966; Cumming and Keynes, 1967) is made. That the experimental group is superior to other sedentary children is not surprising since the test item is purported to measure agility which is necessary for hockey players to be successful since the game demands many starts, stops, fakes, turns and quick changes of direction.

The reason that the difference is not as marked on this item as much as others could be due to the fact that the test is too short thereby not including enough of the previously mentioned components to separate the more agile from the average or less agile individual. Perhaps when dealing with hockey players it is of greater value to use an agility test specific to ice hockey.

Nevertheless, when the children are compared to the Canadian norms (Hayden and Yuhasz, 1966), they are superior. From these results it is evident that the experimental and the control groups from the present study are more agile than the normal sedentary boy of the same age if the shuttle run can be accepted as an adequate measure of agility. The experimental group begins and ends at a superior level suggesting the possibility once again of greater genetic endowment.

Figure 10


14.0
13.0
12.0
11.0
10.0
Means of Shuttle Run vs. Age
Time (seconds)
● Present Study (N = 60)
■ Control (N = 22)
□ Canada (N = 2,110)
▲ Winnipeg (N = 117)
8
9
10
11
Age in Years

The superiority of the experimental group may perhaps have been born out to a greater extent with a slightly longer agility test.

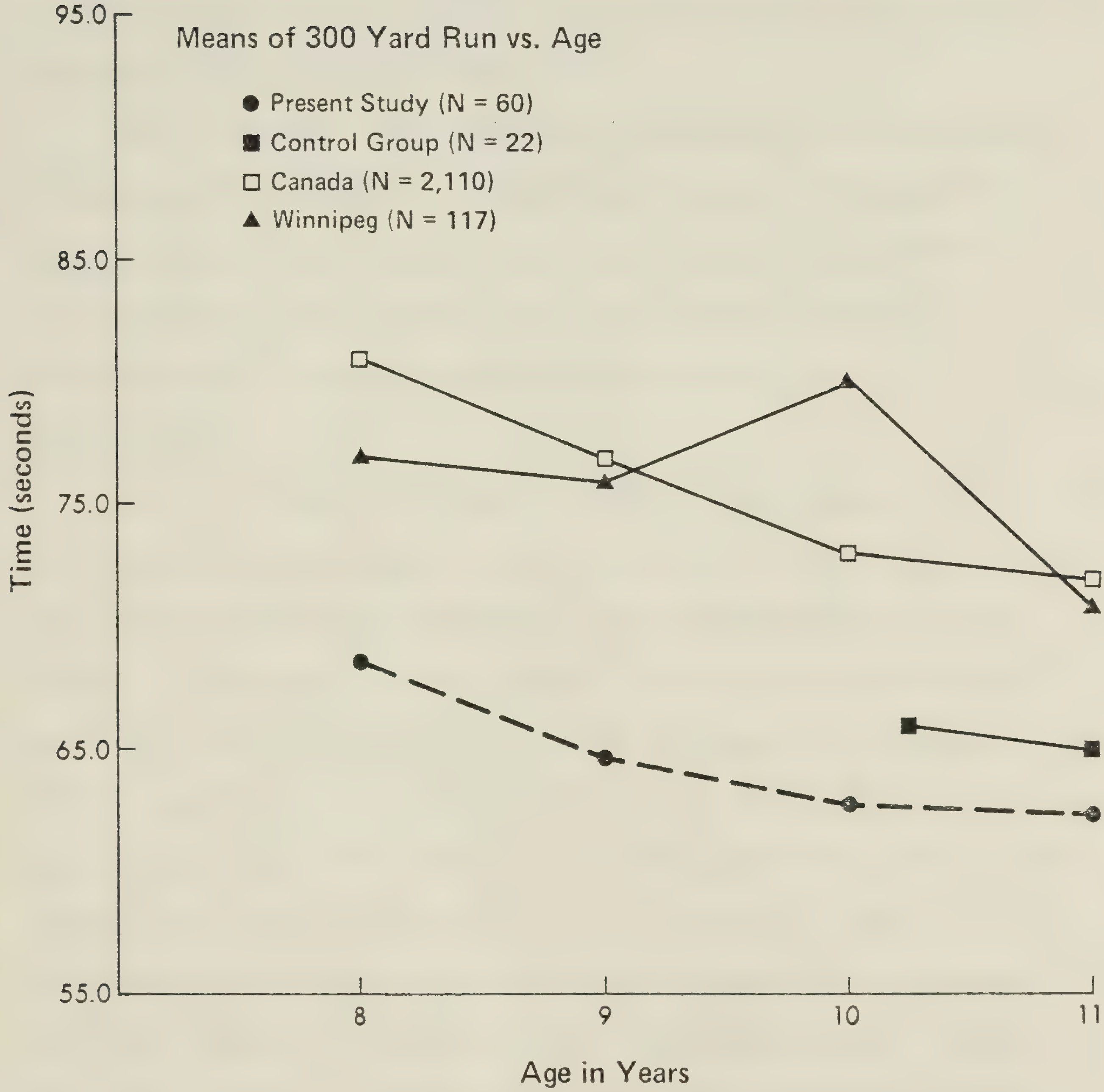
300 Yard Run

Again, as can be seen in Figure 11, the experimental group dominates with lower scores throughout the four year span. In addition, the control group fairs quite well against the Canadian norms (1966) and Cumming and Keynes group (1967).

When the CAHPER manual was published, the 300 yard run was included in the battery of tests as an endurance measure. Since then, however, researchers have come to realize (Cumming and Keynes, 1967; Olrec, et al., 1965; Falls, et al., 1966; Docherty and Colliss, 1976) that the 300 yard run as well as the other items of the battery of tests do not correlate with MVO_2 tests very well. Correlations as low as -.168 with a PWC_{170} test (Docherty and Colliss, 1976) have been found leading researchers to the conclusion that the 300 yard run is an inadequate measure of aerobic power. Therefore, from these findings, researchers cannot infer anything about the cardiorespiratory fitness of subjects with this measure.

From the knowledge gained over the years as to the time-intensity relationships and the degree of participation of the different energy delivery systems (Fox and Mathews, 1974) it is more likely that the 300 yard run measures the predominant anaerobic component of an individual rather than the aerobic component. If this is indeed the case, then it is perhaps not surprising that the scores of hockey players of the present study are superior to somewhat more normal children (Hayden and Yuhasz, 1966; Cumming and Keynes, 1967) since

Figure 11


Means of 300 Yard Run vs. Age
Present Study (N = 60)
Control Group (N = 22)
Canada (N = 2,110)
Winnipeg (N = 117)
95.0
85.0
75.0
65.0
55.0
Time (seconds)
8
9
10
11
Age in Years

hockey studies seem to indicate a great degree of anaerobic involvement as well as the aerobic energy transport system (Green, et al., 1976; Houston and Green, 1975; Seliger, et al., 1972). Whether the superiority of the hockey players of the present study is due to heredity or to training or to both is impossible to determine on the basis of the findings of the present study.

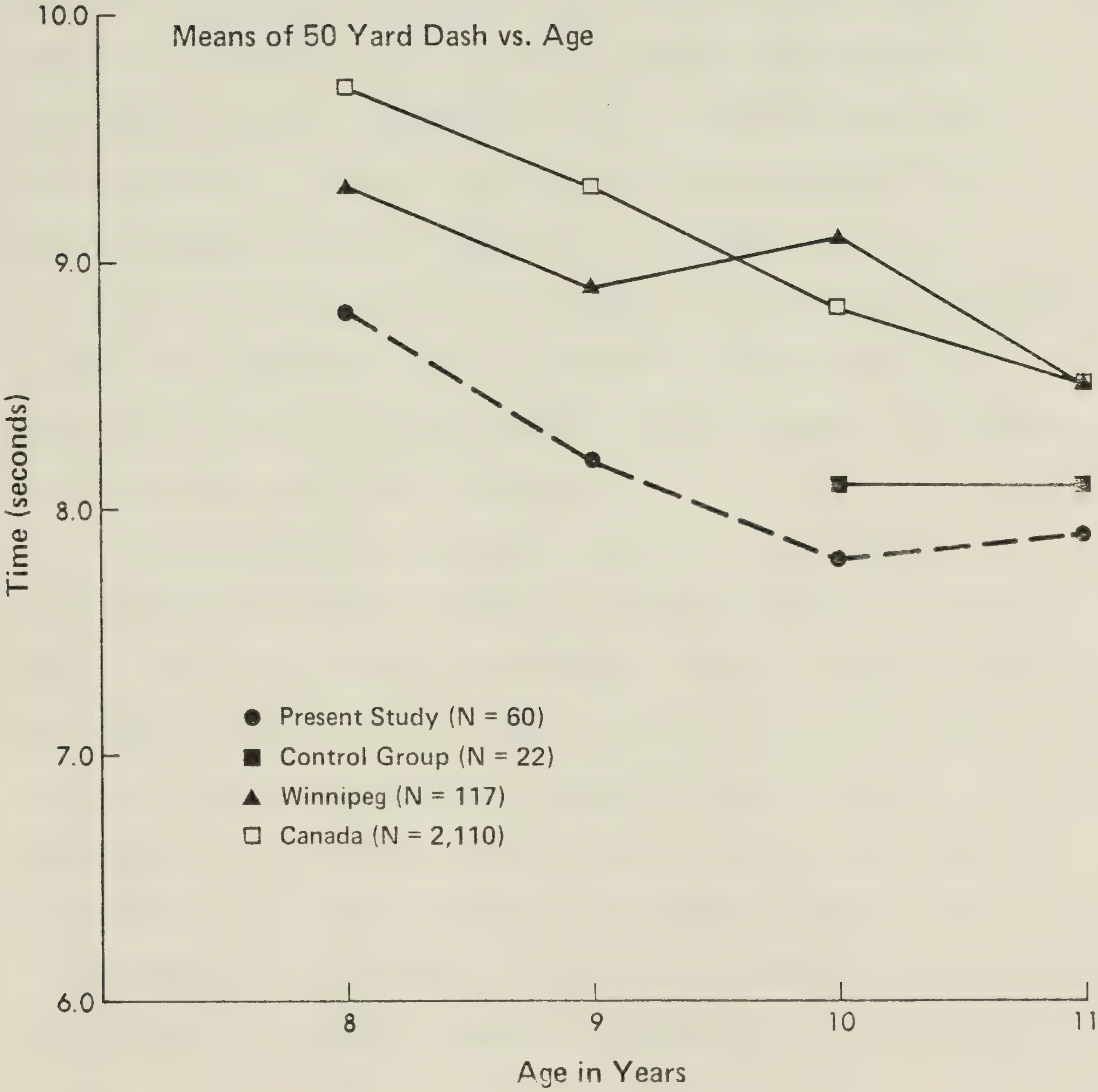
One additional factor that could contribute to the superiority of the subjects in the present study is motivation. Throughout the study the boys were paired to create a more competitive atmosphere and, in addition, verbal encouragement was constantly voiced by the testers and other subjects awaiting their turn to run.

50 Yard Dash

The 50 yard dash in Figure 12 is typical of the graphs that have already been discussed in that the subjects of the present study again demonstrate greater achievement levels when compared to other findings. The pattern of development is almost identical to that of the 300 yard run except that the experimental group seems to regress a little at age eleven. The significance of the differences in this graph are perhaps a little more questionable than others since we are dealing with a range of one half to a little over one second difference between the experimental group and the Canadian norms (Hayden and Yuhasz, 1966) and Winnipeg children (Cumming and Keynes, 1967). Virtually no difference exists between the experimental and control groups.

The 50 yard dash, however, does mimick the short bursts of speed needed in the sport of ice hockey since players must often

Figure 12



10.0
9.0
8.0
7.0
6.0
Time (seconds)
Means of 50 Yard Dash vs. Age
Present Study (N = 60)
Control Group (N = 22)
Winnipeg (N = 117)
Canada (N = 2,110)
8
9
10
11
Age in Years

cover long distances over short periods of time on the ice and in this respect the difference between the hockey players and the other groups seems to take on greater significance.

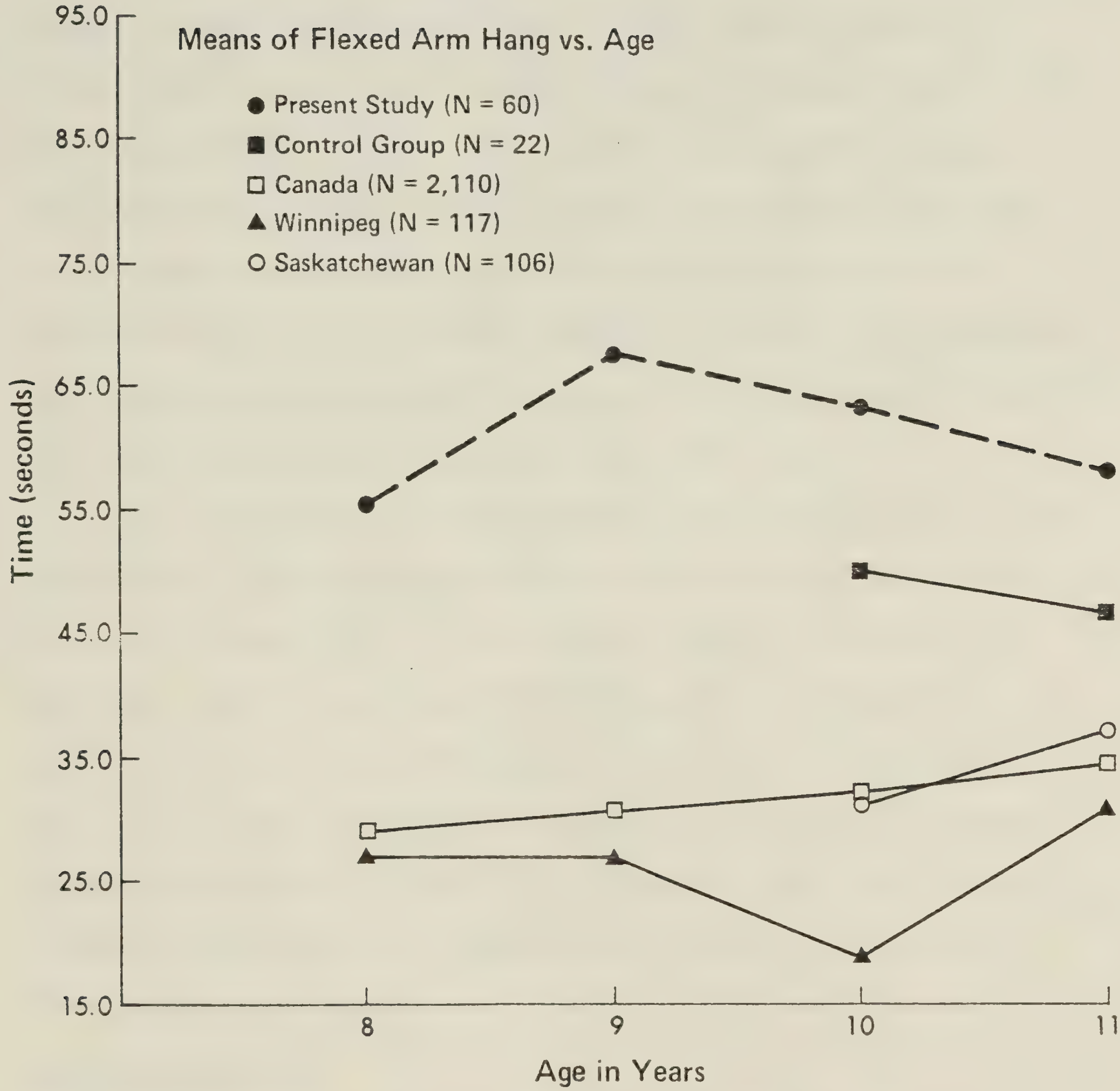
The 50 yard dash can also be said to be a measure of muscular power since it measures the force required by the body to propel itself over a distance of 50 yards in as little time as possible. The force component of the power equation is as yet immeasurable in the 50 yard dash. Kalamen (1968) has correlated the 50 yard dash with the Margaria anaerobic power test and a three step six meter test similar to Margaria's. Correlations of .874 and .974 respectively were found in Kalamen's study. Anaerobic power has not been adequately measured as of yet, however, and the Margaria and Kalamen tests themselves have some limitations.

Macnab (1967) once stated in a commentary that "The item which best correlates to running two miles is the time required to run two miles ... thus in predicting performances, aerobic capacity, at best only imitates specific tests". This comment can also be applied in the case of the 50 yard dash as a measure of anaerobic power. The performance of the 50 yard dash correlates best with itself and the use of the 50 yard dash to evaluate the anaerobic power of individuals is inappropriate. Furthermore, relative to ice hockey, the 50 yard dash at best only mimicks a component characteristic of play during a game.

Flexed Arm Hang

The graphs of the flexed arm hang (Figure 13) are unique in that the superiority of the experimental group is never more marked.

Figure 13


Means of Flexed Arm Hang vs. Age
Present Study (N = 60)
Control Group (N = 22)
Canada (N = 2,110)
Winnipeg (N = 117)
Saskatchewan (N = 106)
95.0
85.0
75.0
65.0
55.0
45.0
35.0
25.0
15.0
Time (seconds)
8
9
10
11
Age in Years

The range of variability with other findings (Hayden and Yuhasz, 1966; Ellis, et al., 1975; Cumming and Keynes, 1967) extends from 23 seconds to 35 seconds at one point in the study.

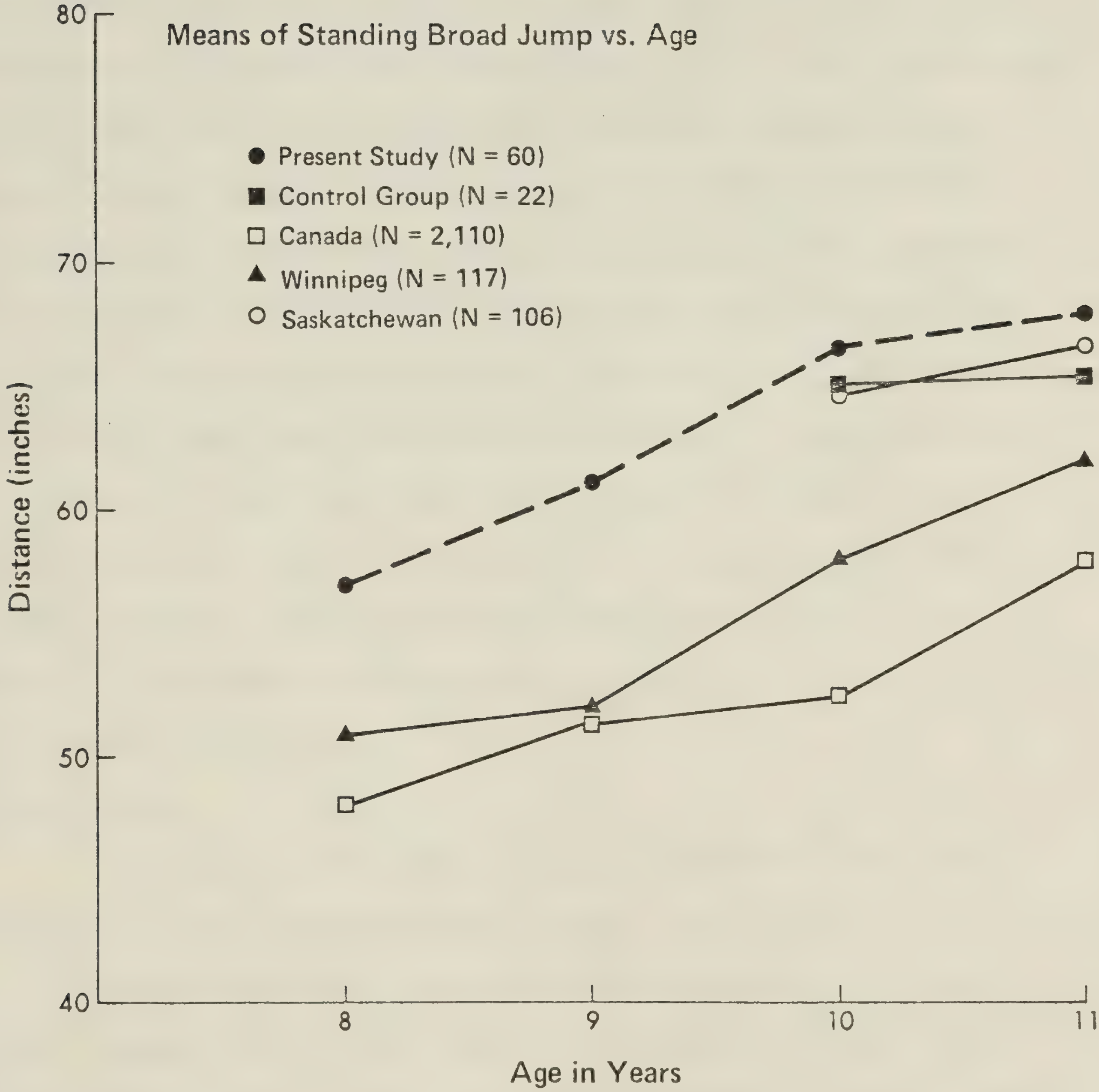
Hypotheses as to reasons for such a great difference are difficult to make in physiological terms. The flexed arm hang is probably best defined as an isometric muscular endurance item of the arms and shoulders, however, this measure like the other measures of the CAHPER battery remain undefined today. The nature of the game of ice hockey requires constant use of the forearms, arms, and shoulder muscles for stickhandling, passing, shooting, fore checking, back checking and body checking and greater strength to accomplish these tasks could account for some of the difference.

The large degree of variability in Figure 13, however, is more likely due to high motivational levels that existed in the subjects used in the present study. When looking at raw data from year to year great variability exists from individual to individual with ranges of 18.9 to 29.9 in the standard deviations over the four year span. Such great inter-individual variability can only be hypothesized as being due to motivational differences. This measure exemplifies the importance that motivation may have had in the other CAHPER performance measures.

Standing Broad Jump

Kalamen (1968) has suggested that the standing broad jump is not an acceptable measure of muscular power since it does not record in power units and does not take weight and speed into account. Nevertheless, it is a measure of leg strength or explosive power since

Figure 14


Means of Standing Broad Jump vs. Age
Present Study (N = 60)
Control Group (N = 22)
Canada (N = 2,110)
Winnipeg (N = 117)
Saskatchewan (N = 106)
80
70
60
50
40
Distance (inches)
8
9
10
11
Age in Years

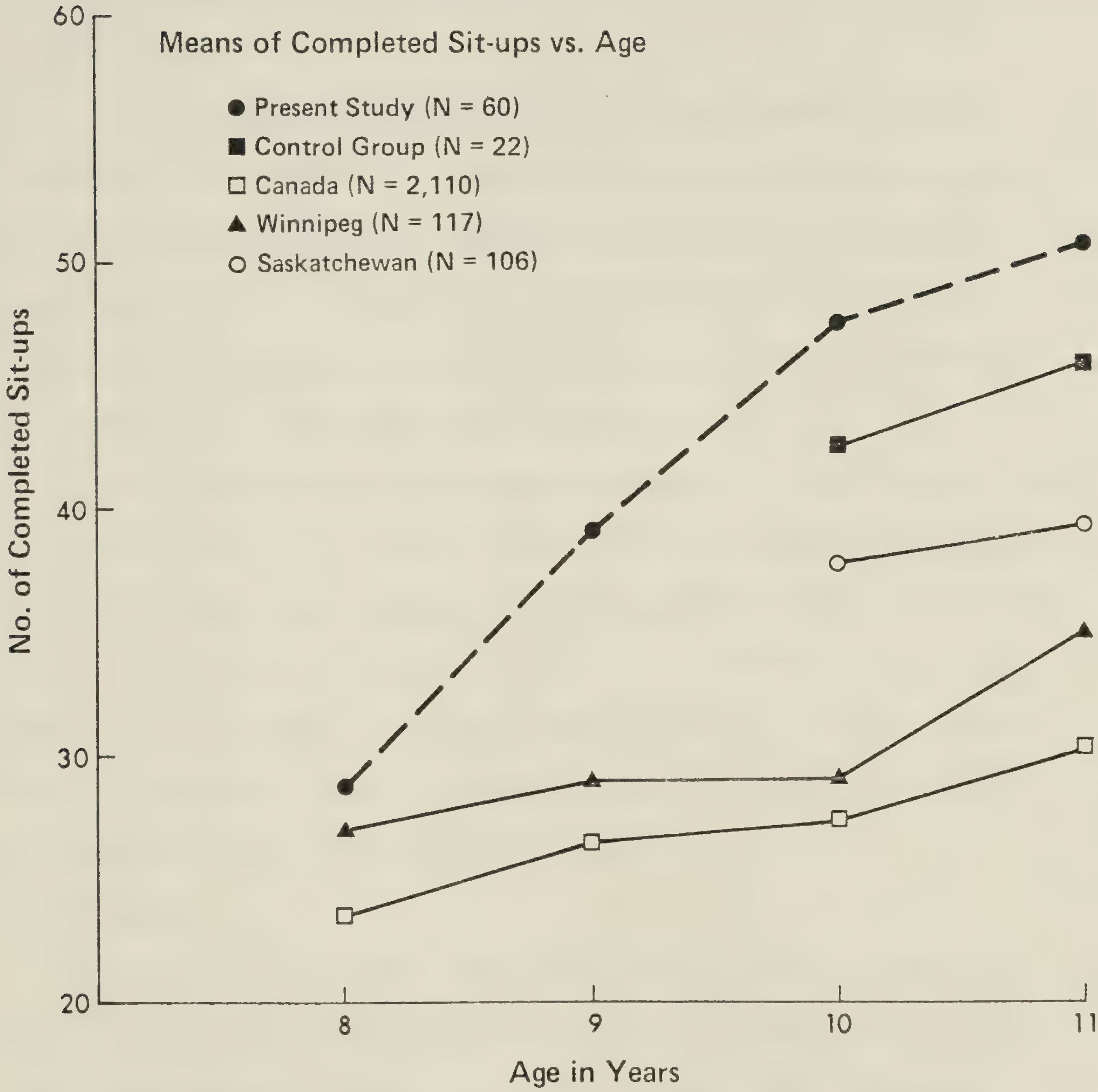
it indirectly measures the force generated by monitoring the distance covered in the jump.

The experimental group again dominates with achievement levels much higher than those of the Canadian norms (Hayden and Yuhasz, 1966) and the Winnipeg sample (Cumming and Keynes, 1967) as can be seen in Figure 14). The Saskatchewan sample (Ellis, et al., 1975), on the other hand, cannot be considered lower since this group, along with the control group at ages 10 and 11, closely approximate the scores of the experimental group. The slope of improvement in the experimental group is normal when compared to the Canadian norms and the Winnipeg children, but they begin at a highter level and remain higher throughout the four year span indicating an improvement of greater magnitude. The reason for the higher scores in the Saskatchewan group are not easily explained. One can only speculate in saying that the Saskatchewan children, like the experimental and control groups, are not typical of the normal population with respect to their ability in the standing broad jump.

Speed Sit-Ups

The results of the speed sit-ups in Figure 15 are the most unique of all the CAHPER performance items. From year to year not only does the experimental group show superiority, but unlike the other figures, there is also a marked interaction with other groups especially the Winnipeg and Canadian groups (Cumming and Keynes, 1967; Hayden and Yuhasz, 1966). The graph of the sit-ups depicts a relative equality from the first year and progresses to a very large difference in year four.

Figure 15


Means of Completed Sit-ups vs. Age
Present Study (N = 60)
Control Group (N = 22)
Canada (N = 2,110)
Winnipeg (N = 117)
Saskatchewan (N = 106)
No. of Completed Sit-ups
60
50
40
30
20
8
9
10
11
Age in Years

Speed sit-ups are a measure of the muscular endurance of the abdominal muscles. The significant interactions from year to year between the experimental, the Canadian and Winnipeg group lead one to the temptation of making cause and effect statements, however, just what caused the observed effect in Figure 15 cannot presently be identified.

It is quite likely that the activity levels achieved from playing ice hockey has had an overall effect on upper body strength including abdominal muscles, however, participation in the sport cannot specifically be shown to be the activity necessary for such increases. Motivation may also have been a contributing factor in this measure as in the case of the flexed arm hang.

The control group from Figures 5 through to 15 have demonstrated a relatively parallel although slightly inferior progression from years 10 to 11 in the present study. The Winnipeg and Canadian groups also fare much lower than the control group. It is possible, from these observations, that the populations being compared are quite different and that because of these differences, today's children are perhaps not comparable to children tested ten years ago.

Grip Strength

Figures 16 and 17 show the progression of the left and right hand grip strength between the experimental and control groups and a sample from Oakland, Saginaw and Edmonton (Jones, 1946; Montpetit, et al., 1966; Howell, et al., 1967). These graphs again are typical with the experimental group suprior to all others. It is interesting to speculate the reasons for superiority in this measure, particularly

Figure 16

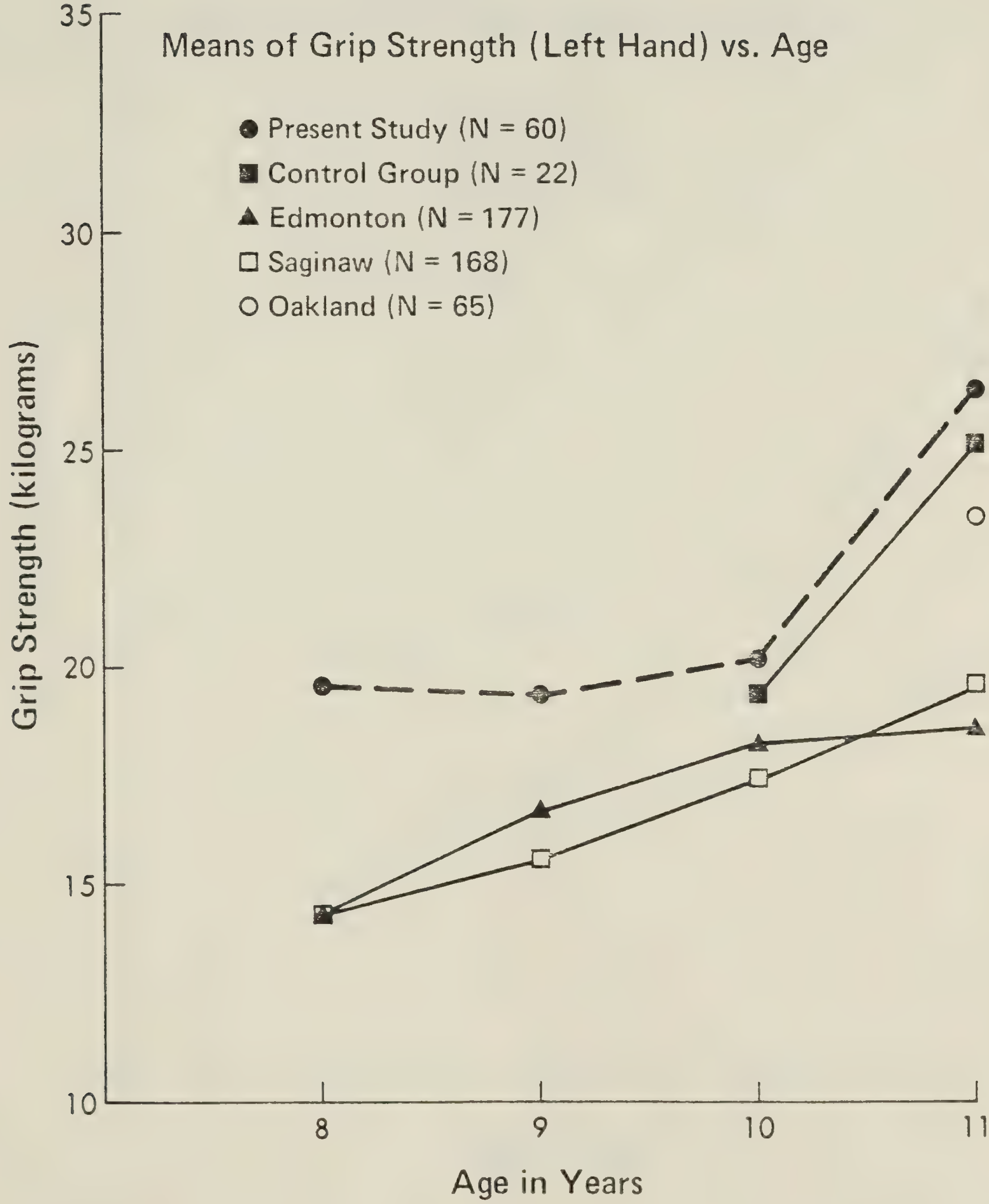
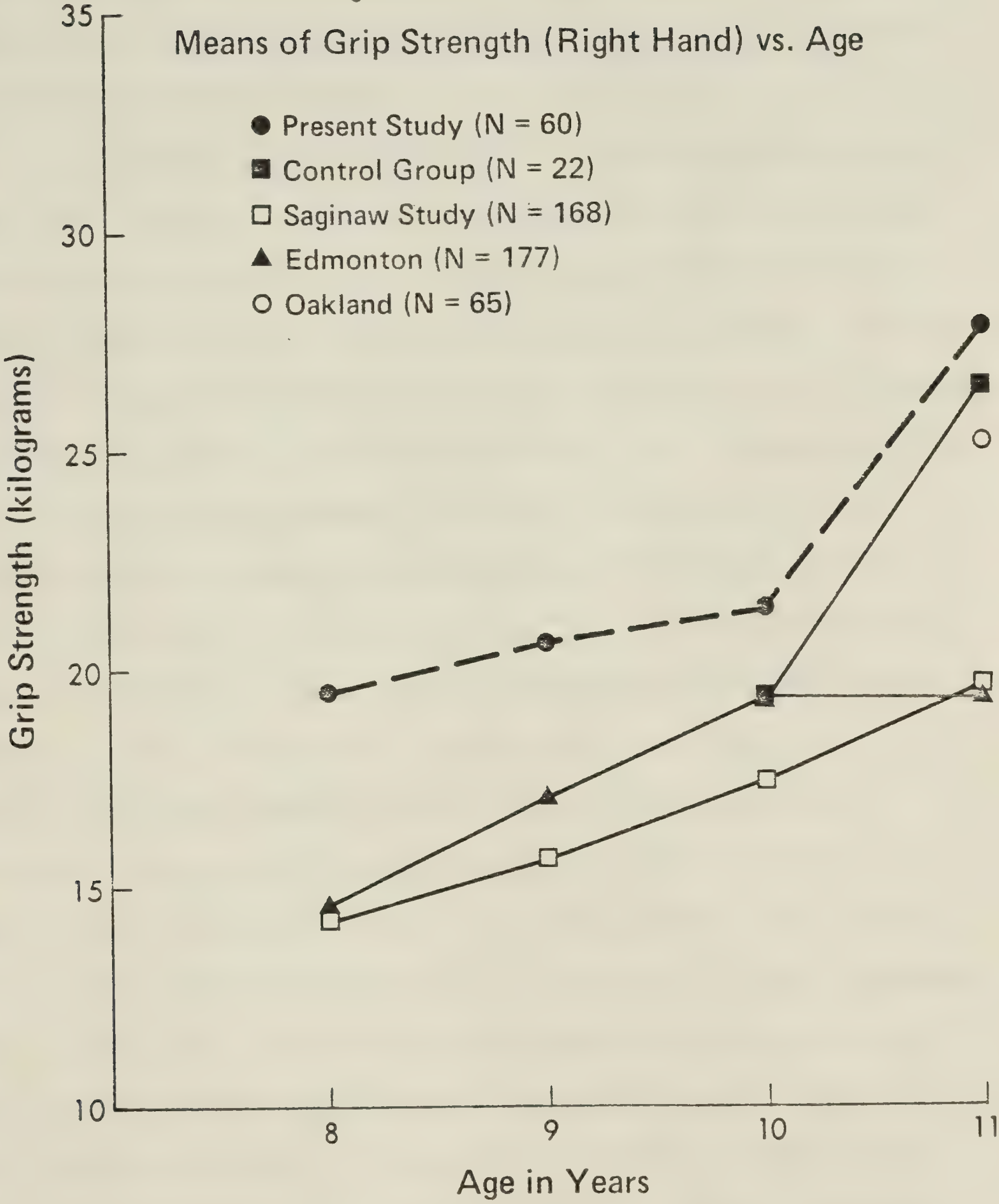

Means of Grip Strength (Left Hand) vs. Age
Present Study (N = 60)
Control Group (N = 22)
Edmonton (N = 177)
Saginaw (N = 168)
Oakland (N = 65)
Grip Strength (kilograms)
35
30
25
20
15
10
8
9
10
11
Age in Years

Figure 17


Means of Grip Strength (Right Hand) vs. Age
Present Study (N = 60)
Control Group (N = 22)
Saginaw Study (N = 168)
Edmonton (N = 177)
Oakland (N = 65)
Grip Strength (kilograms)
35
30
25
20
15
10
8
9
10
11
Age in Years

in relation to ice hockey. As in other sports, ice hockey demands constant use of the forearm flexors to accomplish various tasks and firmly grip the stick simultaneously. Through years of constant participation then, it is not surprising that they possess a stronger grip than more normal children.

It is interesting to note as well, in both Figures 15 and 16, the acute upward inflection of both the experimental and control groups from the third to the last year. In a study by Carron, Bailey and Medhurst (1973) composite strength development was examined longitudinally in a group of boys beginning at age 10 with the study extending up to 14 years of age. The strength measures taken included shoulder, elbow, knee and wrist extension and elbow, hip and wrist flexion. It was found that in a randomly selected sample of 128 boys, 37.4% of the total strength increase over the four year span ocurred between the ages of 10 and 11 years. This was also found to be the largest strength increase from one year to the next in the study. It is possible that grip strength measured in the present study has reflected an increase that seems to occur characteristically at this time in life in boys of that age. It is also possible that playing ice hockey has had a maximizing effect with respect to this phenomenon. When subjects of the present study are compared to the Edmonton and Saginaw sample (Howell, et al., 1967; Montpetit, et al., 1966) the same change is not seen. In the case of the Oakland sample, it is difficult to speculate as to why they approach so closely the groups of the present study since there is no mention of activity patterns or methods of testing in this study.

Montpetit, et al. (1966) in their study compared a 1963-64 population and an 1899 population from the same community. They suggested that the reason that the more recent population had a higher grip strength was possibly due to their greater height and weight. In the present study, the experimental and control groups are from one to six centimeters taller than the Saginaw and Edmonton children, but are only as heavy and in some cases lighter than the latter two groups. From these observations, it is apparent that the differences in grip strength cannot be attributed to stature differences between the groups in Figures 15 and 16.

General Summary

In all of the previously discussed fitness items, some general comments seem appropriate. The sample of the present study is a small one and generalizing from the results is not possible. Because the sample of the present study is of a pure longitudinal type and because most of the other studies deal with cross-sectional samples, comparability between the two is reduced.

A generally consistent pattern of superiority in all fitness tests is evidenced and it is interesting to note that there is a large degree of variability between the experimental group and others in all the different strength measures. Because of high activity levels in the summer in addition to an intensive ice hockey program during the winters, the competitive group demonstrates extremely high fitness levels in relation to other findings.

Hockey Skills Tests

Unfortunately, the only data available for comparison with the experimental group for the hockey skills tests measures is the control group and recently, some unpublished data by Hansen (1978). The results of Hansen's work are presented in Table IX. Two areas will be dealt with in this section. The first of these will be the development of each skill test in the competitive group and Hansen's data. The second section will deal with the effect of a summer's lay-off on the ability to perform the same ice hockey skills.

Development of Ice Hockey Skills

Forward Speed Skating 60', 90', 120'

In this item, measures were taken at 60, 90 and 120 feet. The three measures revealed the same general patterns as can be seen in Figures 18, 19, and 20. For this reason, the discussion will be concentrated on the 90' forward speed skating graph. Figure 19 shows the competitive group with a dotted line surpassing the scores of the control group. Data for only two years exists and the differences are small, varying from .2 seconds at age 10 to .3 seconds a year later. These differences are quite small and cannot be considered significant.

Hansen's (1978) sample which is more heterogenous in nature reveals much slower results with a mean in the 9 to 10 year old age group of 5.5 seconds which is almost 1.3 seconds slower than the competitive group and 1.1 seconds slower than the control group.

In the 120 foot forward speed skating test Hansen's results

TABLE X

Descriptive Statistics on Four Hockey Skill Tests

ATOM

Age in Years	Forward Skating 90'	Backward Skating 90'	Forward Agility	Modified Marcotte's Puck Control
9 - 10	228	228	150	267
N	228	228	150	267
Mean	5.50	10.45	13.77	20.96
Standard Deviation	0.66	4.57	1.87	4.45

PEE-WEE

Age in Years	Forward Skating 120'	Backward Skating 120'	Forward Agility	Hansen's Puck Control
10 - 12				
N	291	287	291	291
Mean	6.58	10.35	12.47	25.28
Standard Deviation	0.75	2.59	1.85	4.55

BANTAM

Age in Years	Forward Skating 120'	Backward Skating 120'	Forward Agility	Hansen's Puck Control
13 - 14				
N	265	267	266	266
Mean	5.83	8.68	10.71	20.86
Standard Deviation	0.57	1.54	1.40	3.28

* Data taken from Hansen (1978).

Figure 18

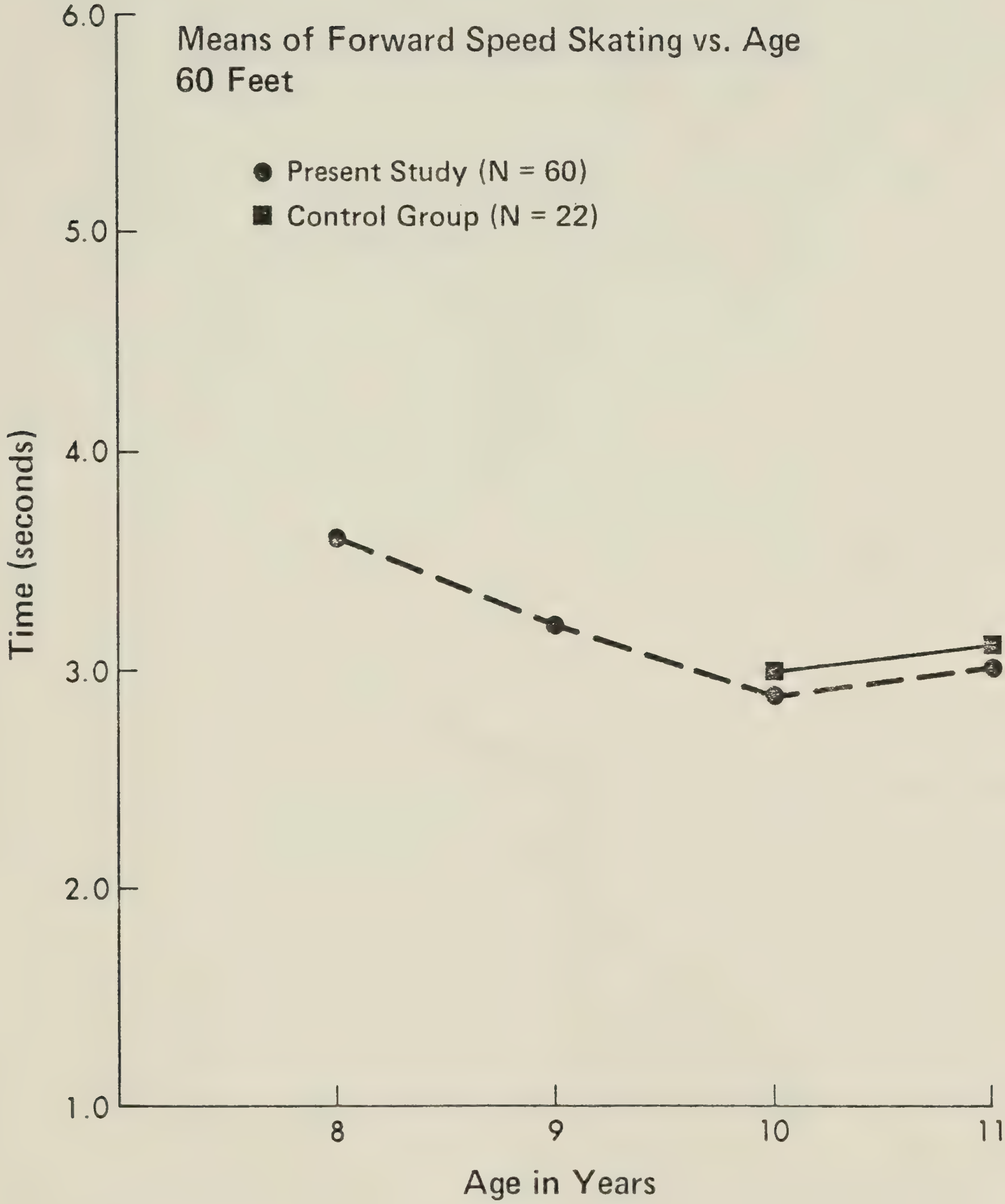

6.0
Means of Forward Speed Skating vs. Age
60 Feet
Present Study (N = 60)
Control Group (N = 22)
5.0
4.0
3.0
2.0
1.0
Time (seconds)
8
9
10
11
Age in Years

Figure 19

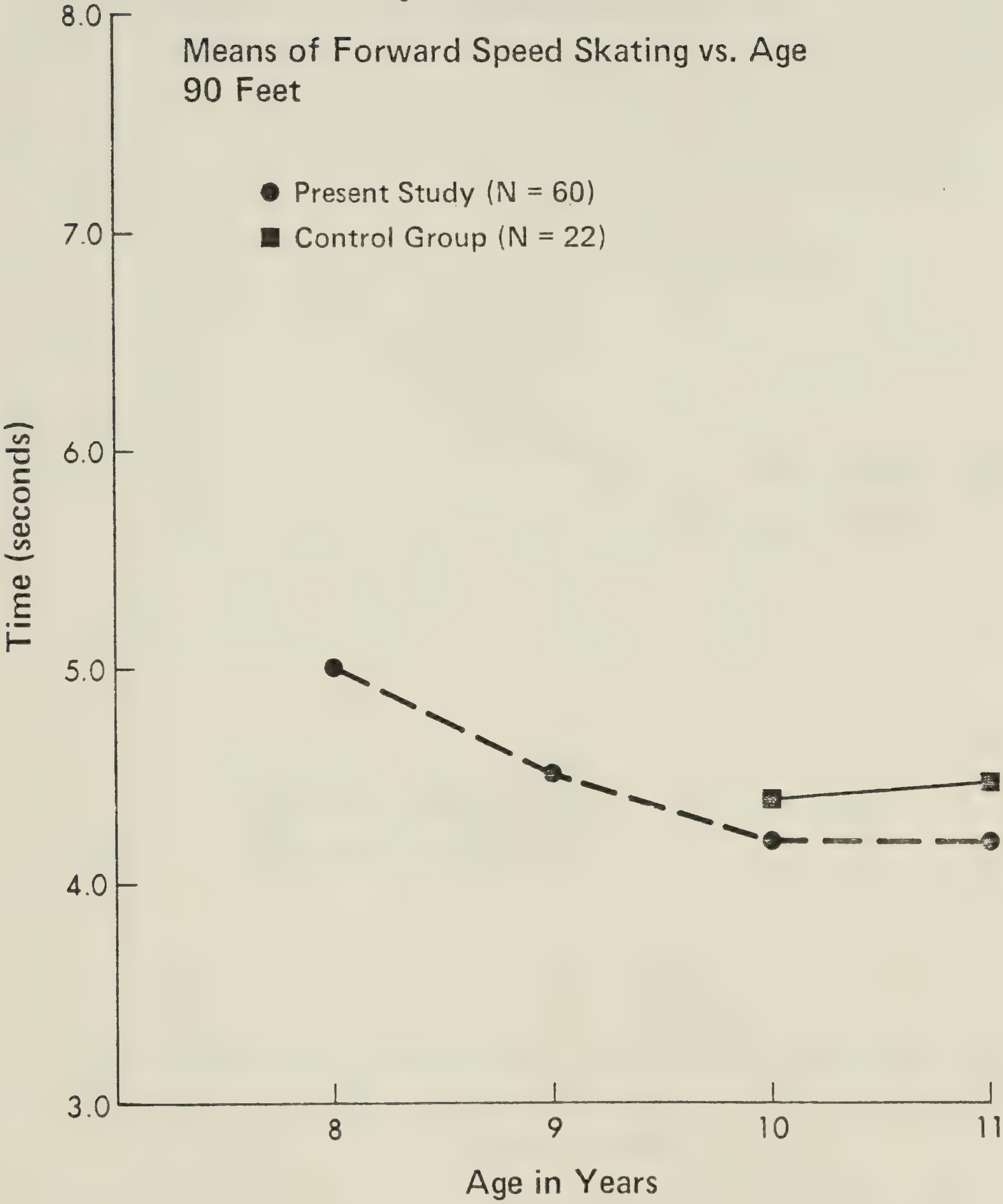
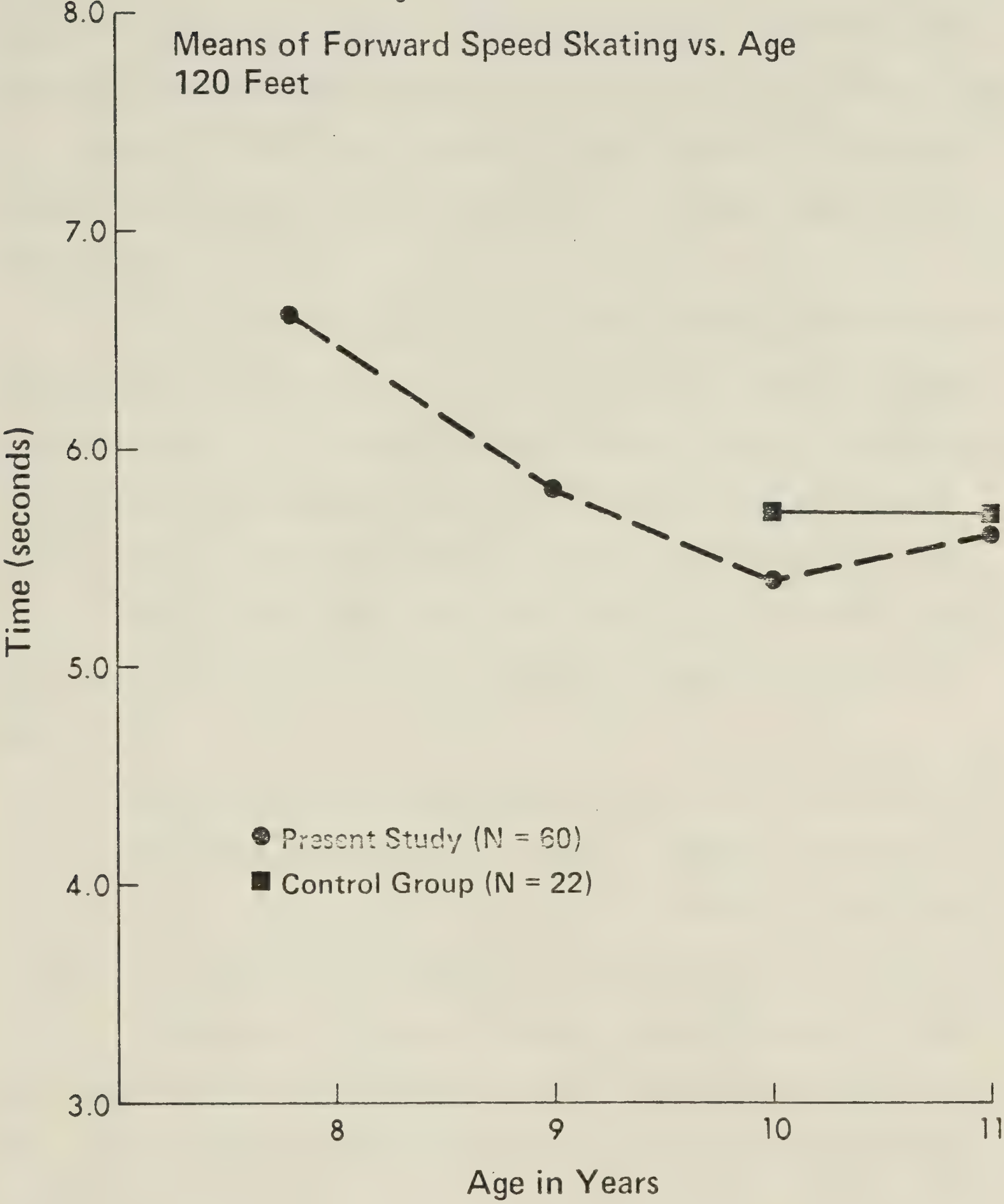

Means of Forward Speed Skating vs. Age
90 Feet
Present Study (N = 60)
Control Group (N = 22)
Time (seconds)
8.0
7.0
6.0
5.0
4.0
3.0
8
9
10
11
Age in Years

Figure 20


Means of Forward Speed Skating vs. Age
120 Feet
8.0
7.0
6.0
5.0
4.0
3.0
Time (seconds)
Present Study (N = 60)
Control Group (N = 22)
8
9
10
11
Age in Years

in the 11, 12, 13, and 14 year old age groups yield means of 6.58 and 5.83 seconds, respectively. Both these groups are slower than the competitive and control groups, though the 13 and 14 year old group approaches but is still inferior to the competitive and control group by .2 seconds. The 11 and 12 year old group, however, is one second slower than the competitive group and .9 of a second slower than the control group.

It is evident from these results that both the competitive and control groups differ from Hansen's group (1978). There are a few possible reasons for these differences. First, Hansen's larger population is more heterogenous and this would give a larger range of values compared to the experimental group which is highly selective. Second, simply because the samples are smaller and more select there would tend to be less variation in ability compared to a larger group.

There are also some limitations to comparing the data from the present study to the data of Hansen (1978). The means of Hansen are based on two age groups rather than just one. Because of this the 9 year old may have increased the mean in the 9 and 10 year old age group. In the other age groups, however, it would be expected that the older boys lower the means. This may have indeed happened, however, even then the older age groups were only equal to the groups in the present study.

With respect to the comparison between the experimental and the control group, not much difference exists. One reason for this

could be that the 90' forward speed skating is not a long enough test to show differences between the two groups. When looking at the means from Figure 20, it is evident that there is still no apparent difference between the groups.

Yates and Macnab (1977), Hansen (1970) and Merrifield and Walford (1971) have shown that forward speed skating yields relatively low validity coefficients ranging from .49 to .77 and (Hansen, 1970) that the reliability of forward speed skating tests is not much better (r = .71). Furthermore, Thibault (1973) found that one season of training had no effect in improving times in forward speed skating tests. The evidence from the studies and the present study seems to suggest that forward speed skating is an inadequate test for differentiating different levels of ability of a hockey player. This could be due either to the shortness of the test or the lack of skills incorporated within the test or both.

Backward Speed Skating 60', 90', 120'

The backward speed skating results depicted in Figures 21, 22, and 23 reveal much the same pattern as in Figures 18, 19, and 20 between the control and competitive groups except that the gap between the groups is larger in the former. The differences in the 90' backward speed skating (Figure 22) is .6 seconds in both comparable years. Similar patterns are evident in the other two backward speed skating figures.

When Hansen's 9 and 10 year old group is compared to the groups in the present study, a much larger difference exists. The mean of 10.5 is from 2.6 to 4.3 seconds slower than the experimental

Figure 21

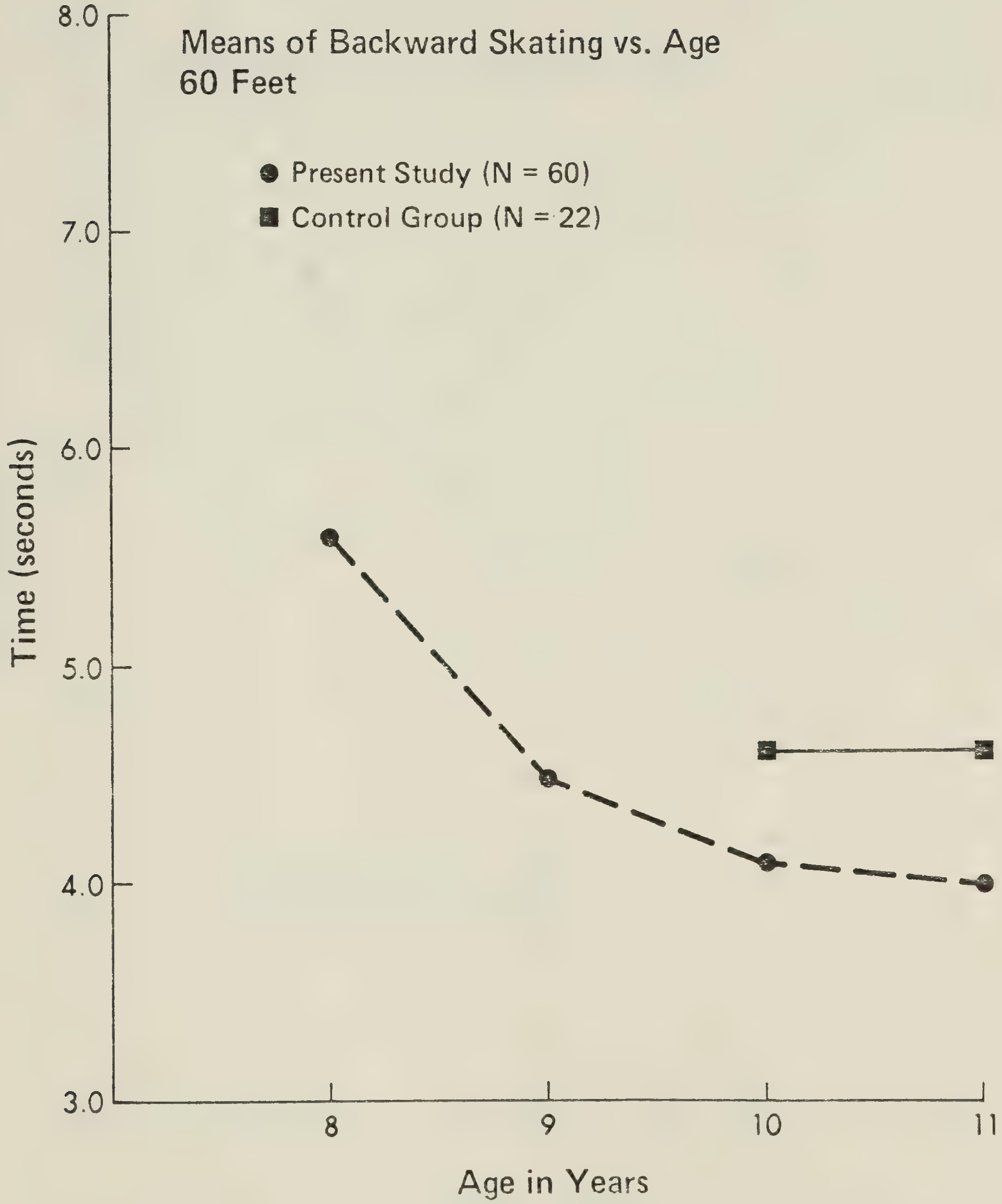

Means of Backward Skating vs. Age
60 Feet
Present Study (N = 60)
Control Group (N = 22)
8.0
7.0
6.0
5.0
4.0
3.0
Time (seconds)
8
9
10
11
Age in Years

Figure 22

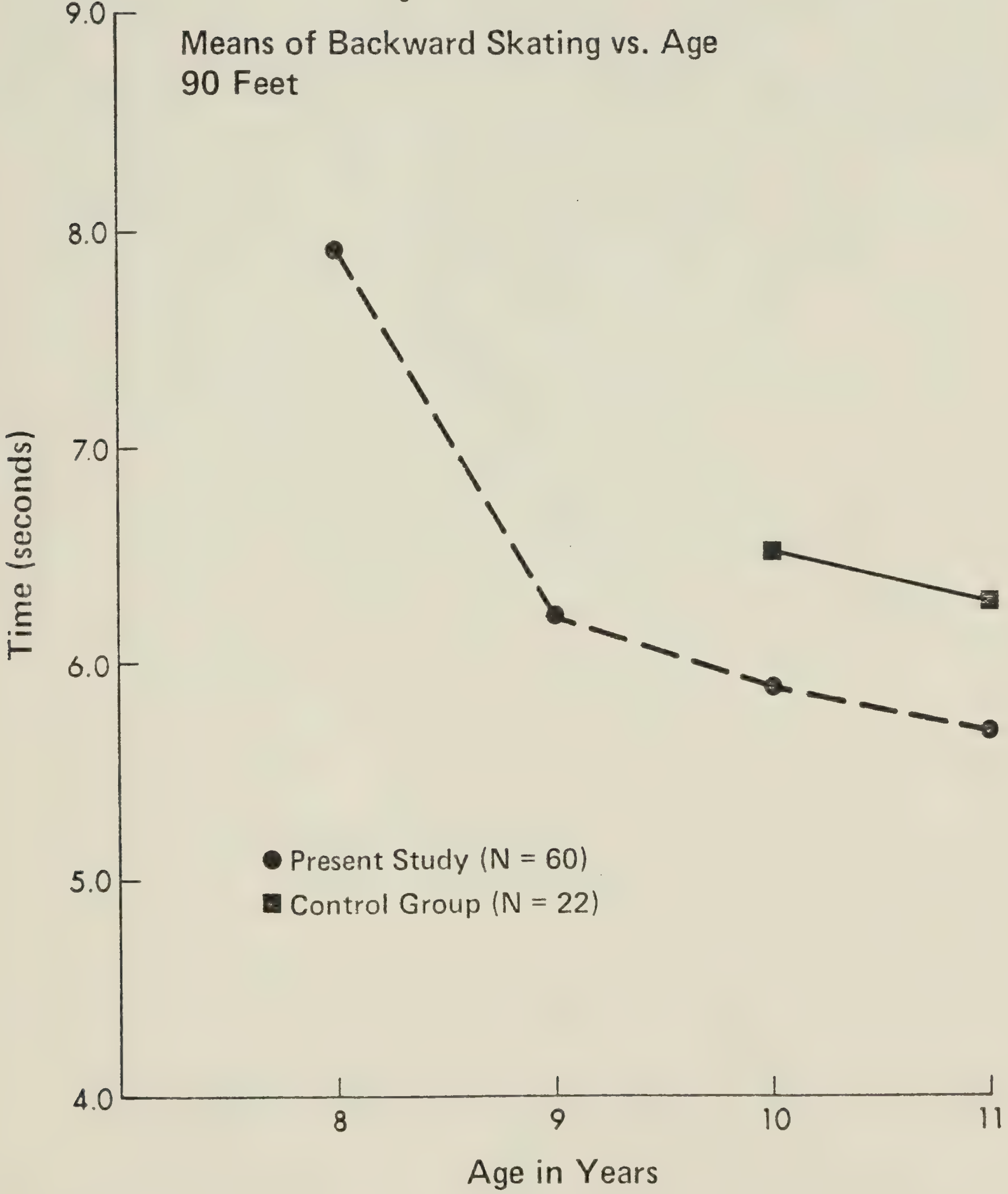
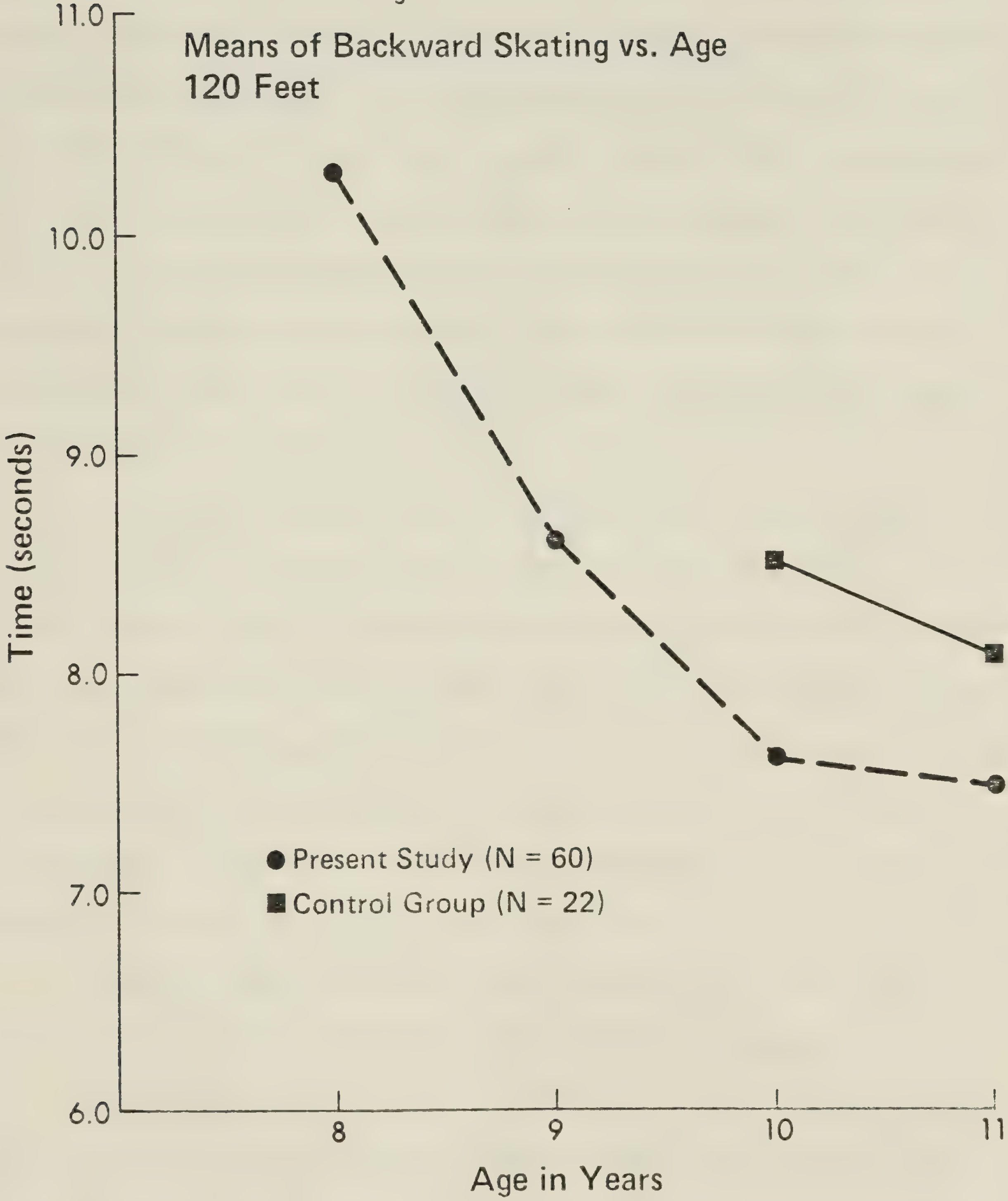

Means of Backward Skating vs. Age
90 Feet
9.0
8.0
7.0
6.0
5.0
4.0
Time (seconds)
8
9
10
11
Age in Years
Present Study (N = 60)
Control Group (N = 22)

Figure 23



Means of Backward Skating vs. Age
120 Feet
11.0
10.0
9.0
8.0
7.0
6.0
Time (seconds)
Present Study (N = 60)
Control Group (N = 22)
8
9
10
11
Age in Years

group at the same ages. In addition, the 11, 12, 13 and 14 year old boys in Hansen's study are from 1.1 to 2.9 seconds slower than the experimental group and from .1 to 2.3 seconds slower than the control group. The skill of skating backwards is probably more difficult to learn since less emphasis is placed upon skating backwards as compared to skating forwards. The boys in Hansen's study (1978) are evidently less skilled at skating backwards than the experimental group. Again, less of a difference exists between the experimental and the control group and just why the latter group does so well relative to other findings can only lead one to the conclusion that the control group is also very proficient.

The control group is still somewhat slower than the experimental group, however, and after retesting this year they are still .5 seconds slower (Macnab, 1978). After five testing sessions it seems doubtful that the experimental group is more familiar to the testing procedure than the control group although it is possible since the experimental group has had five more testing sessions than the control group. Furthermore, both groups of the present study may be in part superior to Hansen's groups because of test familiarity.

Studies (Yates and Macnab, 1977; Hansen, 1970; Merrifield and Walford, 1971) with children and adolescents have revealed that like the forward speed skating tests, backward speed skating tests yield fairly low validity coefficients, these varying from ,62 to .70 and the reliability coefficients for these tests (Merrifield and Walford, 1971; Hansen, 1970) were a little higher (.79 to .84).

Validity studies have some limitations in that they are based

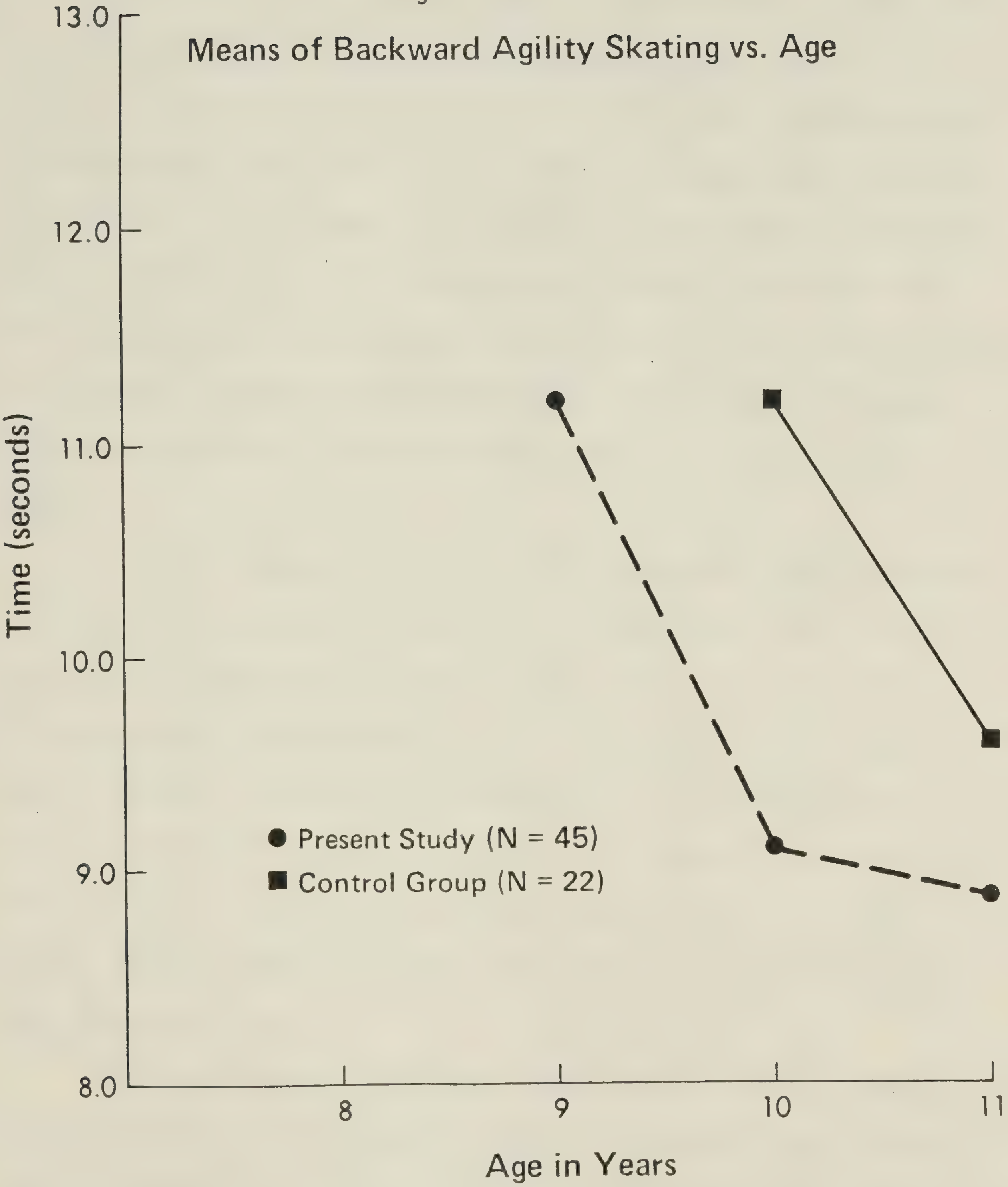
on a subjective evaluation by a group of coaches or a single coach, however, the consistent pattern of relatively low validity coefficients from study to study does supply concurrent evidence as to the weak predictive power of the backward and forward speed skating tests. It is possible that even though the backward speed skating items are better predictors of overall ability in ice hockey than forward speed skating items, they are still not complex enough to measure some of the more important components of a skilled ice hockey player. Both of the first two measures in Figures 18 and 21 are perhaps too specific to be of any use as overall predictors of ability. Nevertheless, when specific groups such as those of the present study are compared to larger, more heterogenous samples such as Hansen's group (1978), these tests become useful for a teacher or coach to compare and evaluate the ability level of their players.

In both the forward and backward speed skate the rate of progression from year to year can be attributed to a variety of factors. One of these could be the combination of growth and maturing. Learning, because of the practice of the skills, is another possible factor. Another possible factor is test familiarity which no doubt has contributed to the year to year improvement in both groups. Finally, in the first year (Thibault, 1973), ice conditions were not optimal and it is likely that the first year of progression was affected in these and all other skills tests that began in the first year of the study.

Backward Agility

This test (Figure 24) was initiated in the second year of the study and measured during the last three. From year 9 to 10 there

Figure 24


13.0
Means of Backward Agility Skating vs. Age
12.0
11.0
10.0
9.0
8.0
Time (seconds)
Present Study (N = 45)
Control Group (N = 22)
8
9
10
11
Age in Years

seems to be a greater separation developing between the experimental and control groups. At age 11 the control group is still inferior to the experimental's tenth year results by .5 seconds.

This test is more complex than the others as can be seen from the diagram (Figure 3) of the backward agility skating and in both groups the first to the second year of testing reveal large decreases indicating that there must be a substantial learning effect occurring from one year to the next. With more testing sessions it is possible that the control group would approach the means of the experimental group much more closely. Another measurement this year (Macnab, 1978) has revealed a continuing large decrease (9.6 to 8.5) in the means of the control group and the experimental group (8.9 to 8.0) on this item.

This test measures the ability to incorporate lateral movement (backward cross-overs) with the skill of backward skating. The present results would seem to indicate that part of the superiority of the experimental group is due to test familiarity but with such a gap (.7 seconds at the end of the study), part of the difference is likely due to the variability in skill level between the two groups. Skills practice, growth and maturation have played a role in both groups, however, the experimental group has had much more practice than the control group.

Yates and Macnab (1977) have found that this test is a good predictor of performance combining with the Marcotte's puck control to yield a correlation of .93 in multiple regression analysis. The Macnab and Gill backward agility test itself correlated (.85) quite well with

the coach's subjective evaluation of performance. Further work is needed, however, to ascertain these results.

Forward Agility Skating

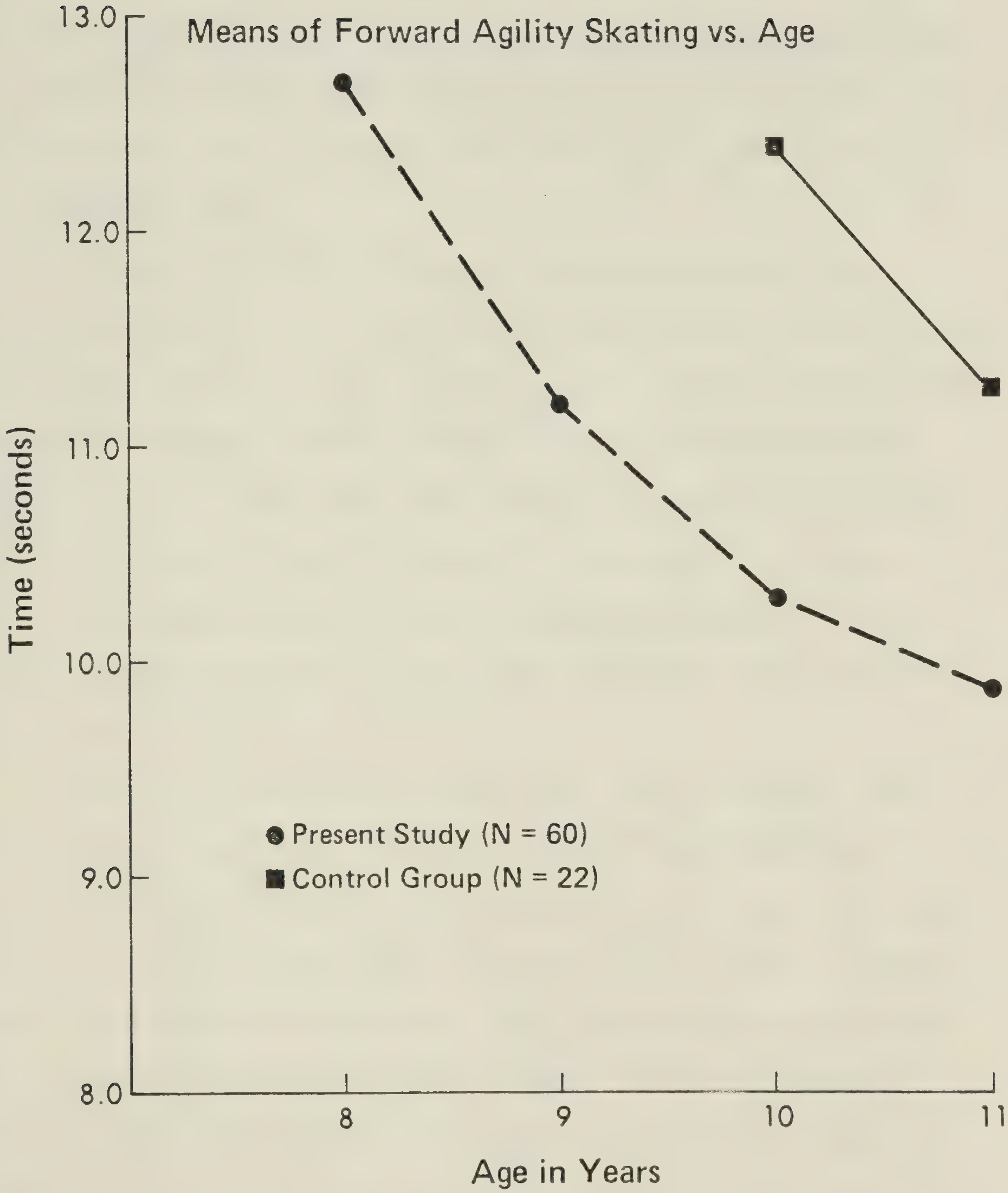
In Figure 25 we can see that the gap is widening between the experimental and the control group. Again, the complexity of the test is greater and this is likely responsible for a large part of the difference between the two groups. The means of the dominating experimental group differ with those of the control group by 2.1 and 1.4 seconds in years 10 and 11, respectively.

From the first to the second year of the study part of the difference could be due to the improved ice conditions in the second year of testing (Thibault, 1973). It is interesting to note here once again that the 9 year olds from the experimental group are still superior to the 11 year olds of the control group, however, a large part of this could be due to test familiarity.

This year's pre-season data (Macnab, 1978) indicates that the two groups are still 1.4 seconds apart. After five testing sessions, test familiarity may be a factor, but part of the difference is very likely due to the fact that the experimental group has more skilled skaters. When looking at each group individually, year to year progressions could be attributed to a combination of growth maturing and skills practice.

When both of these groups are compared to the groups in Hansen's study (1978), it is interesting to find that both groups of the present study are consistently superior. Hansen's 9 and 10 year old group is slower than the 10 year old control group by 1.4 seconds and by 2.6

Figure 25


Means of Forward Agility Skating vs. Age
13.0
12.0
11.0
10.0
9.0
8.0
Time (seconds)
8
9
10
11
Age in Years
Present Study (N = 60)
Control Group (N = 22)

seconds and 3.5 seconds at ages 9 and 10 with the experimental group. The 11 and 12 year old group in Hansen's study is 1.1 seconds slower than the 11 year old control group, but Hansen's 13 and 14 year olds are .4 seconds faster than the 11 year old control group. When these age groups are compared to the experimental group at age 11, the 11 and 12 year olds are 2.6 seconds slower and the 13 and 14 year olds are .8 seconds slower.

A large part of the differences here could be due to test familiarity especially with a more complicated test such as the forward agility test. Hansen's group is large and heterogenous in this test like the other groups tested in Hansen's study and the variability in skill level is likely much larger than in the groups of the present study. The 13 and 14 year old group are closing the gap, however, only .8 seconds behind the 11 year old experimental group. This could possibly reflect a growth and maturation relationship with the forward agility test.

Looking at the validity of this test, Yates and Macnab (1977) found a simple correlation of .87 (76% variance explained) with the overall subjective evaluation of performance by the coach. This test did not significantly contribute to the prediction equation of performance. The criterion to accept or reject a variable in the equation was less than a 4% change in the MR. Hansen (1970) has reported a lower validity coefficient of .58 for the same test. From these conflicting results, it is evident that the validity of these tests is still unresolved.

Marcotte's Modified Puck Control

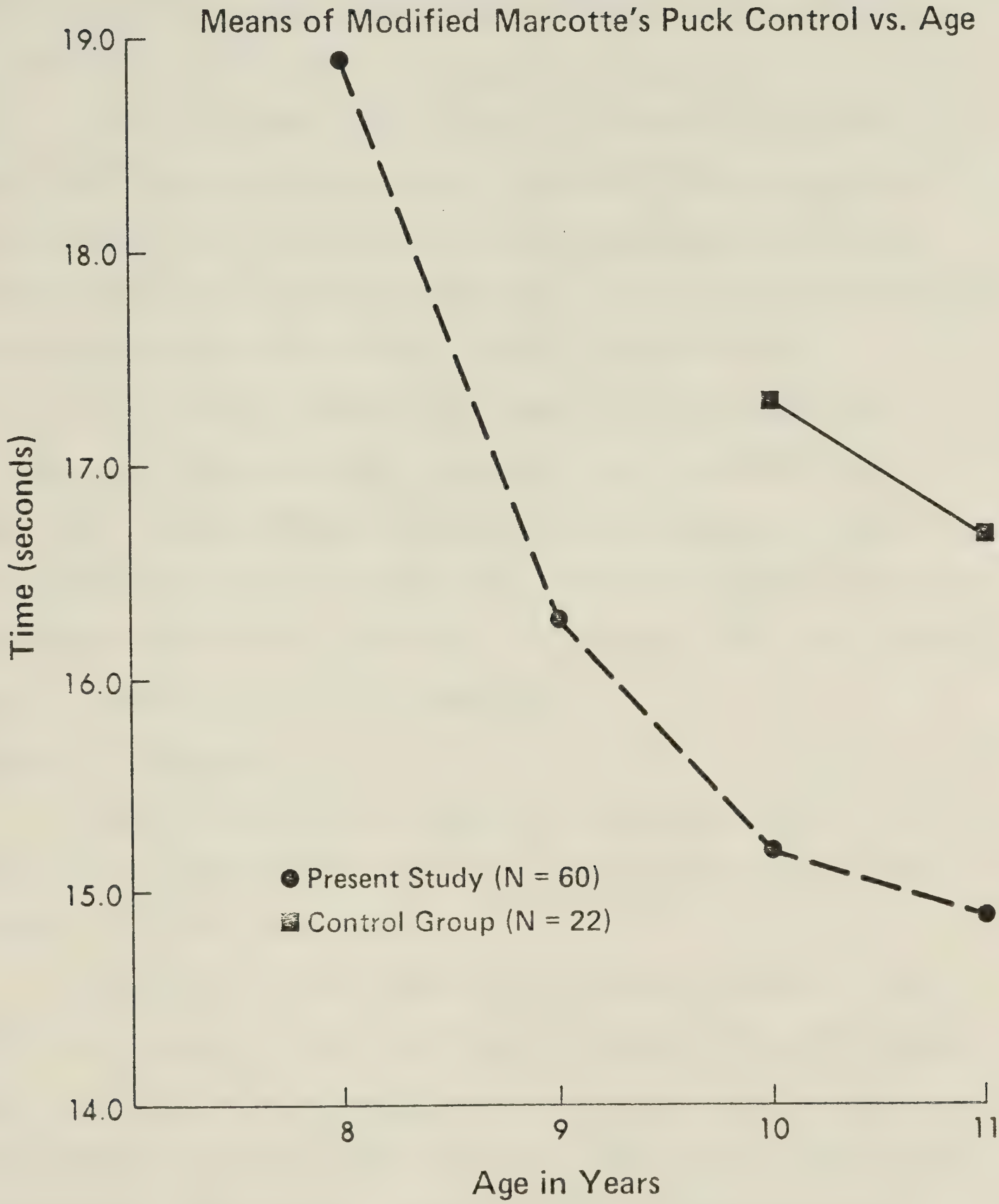
In Figure 26 it becomes evident once again that the complexity of tests will contribute to a larger variability between groups, skill most likely taking on greater importance.

The 10 and 11 year old control group is 2.1 and 1.8 seconds slower than the experimental group at the same ages. The two groups seem to progress at the same rate in the last two years as is evident in the other skills tests.

The reason for part of the differences from the first to the second year is likely due to better ice conditions in the second year (Thibault, 1973). The reasons for the differences between the two groups are the same as in the other tests, however, we see a more pronounced difference with this test compared to the others. This year's means (Macnab, 1978) show the same type of progression and differences between the two groups (Control = 15.5, Experimental = 13.5). When the 9 and 10 year old group from Hansen's study is compared to the control and experimental group it can be seen that once again Hansen's children are slower. With respect to the experimental group, Hansen's group is 4.6 and 5.7 seconds behind the 9 and 10 year old experimental group. The control group at age 10 is also superior by 3.6 seconds.

Here again, test familiarity probably accounts for some of the difference, however, the increased difference that accompanies the increased complexity of each test indicates that a skill level difference likely exists. Skating and turning around cones with the added component of handling a puck is definitely more difficult than doing the same types of turns and strides without a puck and requires greater

Figure 26


Means of Modified Marcotte's Puck Control vs. Age
19.0
18.0
17.0
16.0
15.0
14.0
Time (seconds)
8
9
10
11
Age in Years
Present Study (N = 60)
Control Group (N = 22)

skill from the individual executing the test. This is evidenced by the results of Figure 26 between the experimental and control group and further by the comparison of these results to those of Hansen (1978).

Yates and Macnab (1977) attempted to establish the validity of this test along with the others and found that it contributed 81% of the variance in a simple correlation with performance. Along with the Macnab and Gill backward agility test, it contributed significantly to the performance with an MR of .93 (86% of the variance).

Merrifield and Walford (1971) found validity coefficients ranging from .70 to .83 with a puck carry test in children 8 to 11 years old. Hansen (1970) found a validity coefficient of .63 with the Marcotte's Modified puck control test. From this it can be seen that controversy still exists concerning the validity of this test and more work is needed to clarify the situation.

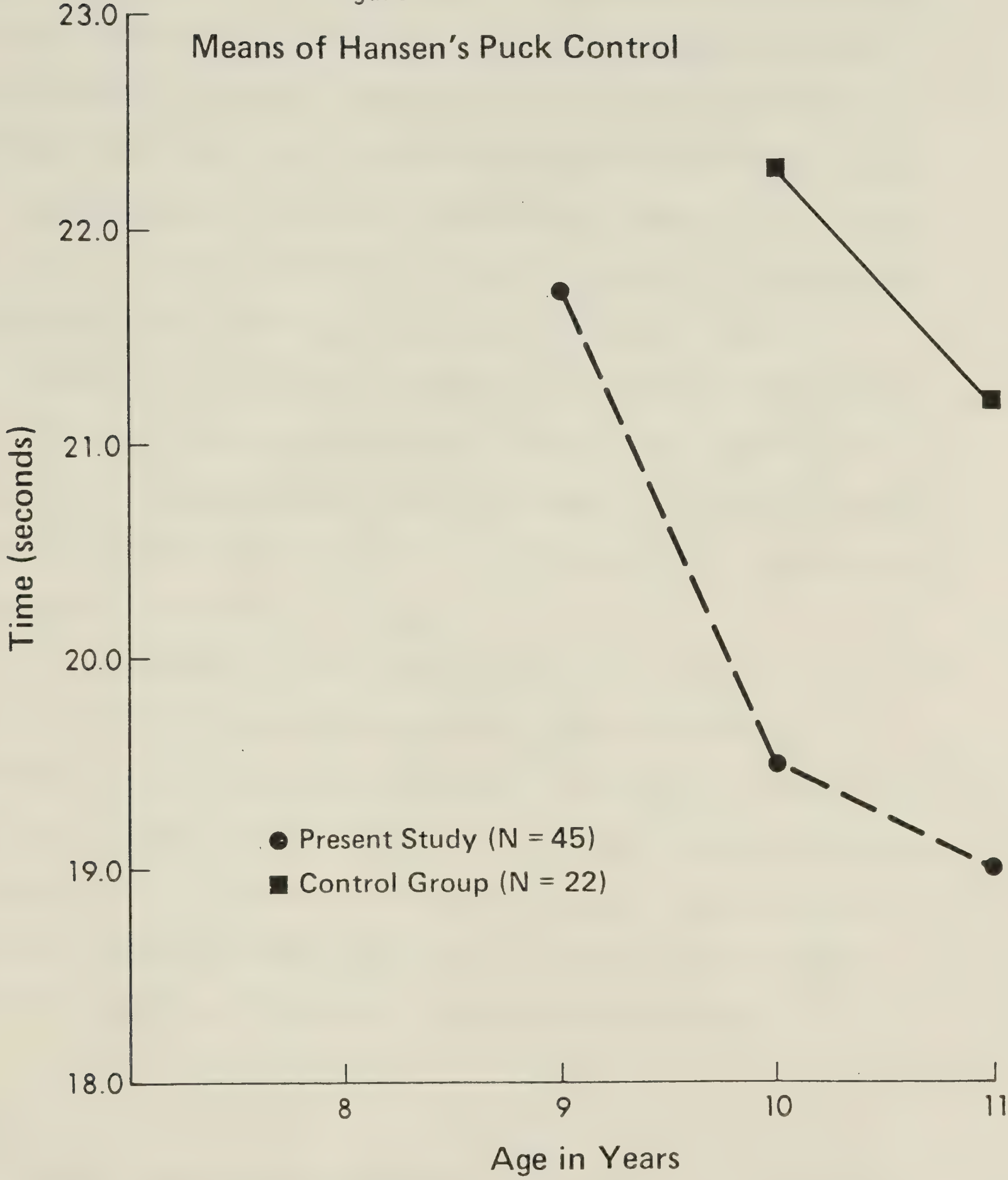
Hansen's Puck Control

Figure 27 depicts the results of Hansen's puck control. The differences between the 10 and 11 year old experimental and control results is 2.8 and 2.2 seconds.

One thing that can be seen in this puck control test is that from the first year to the second year of testing a dramatic improvement occurs in the experimental group whereas this does not occur in the control group to as great an extent. Improved ice conditions were present when this test was added to the study in the second year, ruling out ice conditions as a factor.

The puck control tests are the most complex of all, incorporating

Figure 27



Means of Hansen's Puck Control
23.0
22.0
21.0
20.0
19.0
18.0
Time (seconds)
8
9
10
11
Age in Years
Present Study (N = 45)
Control Group (N = 22)

many components such as hand-eye coordination, skating agility, stopping and starting, turning in both directions and puck control being simultaneous with all of these other skills. The control group is perhaps showing a less dramatic improvement upon first exposure because of less developed skill level. The experimental group, on the other hand, has had a great deal more time to practice these skills and has also enjoyed much more ice time. In addition to skill level, part of the dramatic change is likely due to test familiarity. In the other years, growth and maturing probably play an important role.

When the control group is compared to the 11 and 12 year olds and the 13 and 14 year olds of Hansen's study (1978), the first is found to be 4.1 seconds slower while the second is .3 seconds faster. In the 11 year old experimental group, differences of 6.2 seconds and 1.9 seconds, respectively, are seen.

Yates and Macnab (1977) found that this test had a validity coefficient of .73 with performance while Hansen (1970) found a correlation of .51 which is a considerably lower value. Although this test seems to differentiate between ability levels to a greater degree, it does not seem to correlate well to performance. The correlation is based on a subjective evaluation, though, and more work is needed before the question of this test's validity can be answered.

Summary

In all the ice hockey skills tests discussed, the experimental group surpasses the control group and other findings (Hansen, 1978) including an older 13 and 14 year old age group (Hansen, 1978). The

difference between the competitive and control group becomes greater as the tests increase in complexity. The differences between the groups are likely due to a greater amount of skills practice in the experimental with test familiarity responsible for some of the difference. The year to year progression of the skills tests on the other hand are probably due to learning in all groups, due partly to practice, in addition to growth and maturing.

The validity work that has been done is not conclusive and more work is needed to establish the validity of the skills tests of the present study. When comparing the skills tests results to a control group or to a larger more heterogenous sample, all of the skills tests are purposeful in evaluating the skill level and/or efficiency of the teacher or coach.

Effects of Summer Lay-Offs on Skills Tests

Studies (Meyers, 1962; Ryan, 1962; Purdy and Lockhart, 1962; Ryan, 1965) that have been reviewed have used the term retention to define subjects' abilities to remember and execute different motor skills after periods of no practice. In the present study, to use this term is perhaps inappropriate since the lay-off period was not strictly adhered to. During the summer some of the subjects, especially those from the experimental group, did practice some ice hockey skills by attending hockey schools. Therefore, to use lay-off period, where some practice did occur, is probably a more accurate term.

To record the effect of the summer lay-off period, the decrement or improvement in performance times of the different skills tests means

were recorded from the post-season of one year to the pre-season of the next. The results for the competitive and control groups are given in Table X.

No consistent pattern exists with the experimental and control groups on any of the skills tests monitored. The biggest changes occur in the Macnab and Gill backward agility test with both a decrease of 2.1 and an increase of 1.5 in the experimental group and an increase of 1.4 in the case of the control group.

Studies (Meyers, 1962; Purdy and Lockhart, 1962; Ryan, 1962) generally indicate that periods of lay-offs up to a year in length do not have much effect on the performance of simple motor skills. Ryan (1965) found that a lay-off period of 6 to 12 months deterred stabilometer performance 80% and 50%, respectively. The task in these studies, however, are not related to the skills of the present study. In the past (Meyers, 1962; Purdy and Lockhart, 1962; Ryan, 1962; Ryan, 1965) studies dealing with retention have dealt with adults and growth was therefore not a factor. In the present study, children were used as subjects and growth may have had a masking effect on decreased or increased performance times measured during lay-off periods.

In most of thes tests, a very small change is observed and half of the changes in both the experimental and control groups are improvements rather than decrements in performance.

In the case of the decrements, the differences (.1 to 2.1) could be due to experimenter error or to lack of practice. With respect to lack of practice, it seems unlikely that the summer would

TABLE XI

Mean Changes of Times of Hockey Skills Tests
(Post-Season to Pre-Season)

	Competitive Group			Control Group
Skill Test	'73-74 to '74-75	'74-75 to '75-76	'75-76 to '76-77	'75-76 to '76-77
Forward Speed Skate				
60'	-.3	-.1	0.00	+.4
90'	-.1	+.1	+.2	+.4
120'	-.2	-.3	+.2	0.0
Backward Speed Skate				
60'	-.8	-.1	-.1	+.1
90'	-1.1	+.2	-.2	-.1
120'	-1.1	-.7	-.1	-.3
Macnab and Gill Backward Agility	---	-2.1	+1.5	+1.4
Forward Agility	-.5	+.5	0.00	-.3
Marcotte's Puck Control	-1.6	+.6	-.7	-.5
Hansen's Puck Control	---	+.2	-.6	+.3

* - indicates decrease or improvement in performance time
 + indicates increase or decrement in performance time

have any effect since studies (Ryan, 1962; Meyers, 1962; Purdy and Lockhart, 1962) have shown that subjects are able to retain motor skills for longer lay-off periods than the ones of the present study. In addition, subjects from both groups of the present study did have some practice during the summer hockey schools.

In any case, because of the inconsistent results presented in Table XI, it is impossible to draw any conclusions with regard to the effects of the off-season lay-off periods.

CHAPTER V

SUMMARY AND CONCLUSIONS

After four years of study, some general trends are apparent from the results. Height and weight results suggest relatively normal progressions from year to year relative to other findings. In the cardiovascular measure (PWC_{170}) the importance of physical activity has been substantiated as the boys of the present study demonstrate superiority over most other findings. In addition, the control group is not unlike the competitive group with respect to this measure. On all other fitness measures, the competitive group demonstrates its superiority relative to other findings.

The hockey skills tests reveal a similar pattern as that of the previous measures and the experimental group's domination is emphasized by its superiority over older age groups (Hansen, 1978). As the various skills tests increase in complexity, the difference between groups increases in favour of the competitive group. With respect to the validity of the skills tests, much controversy is still apparent from study to study. Summer lay-offs have no consistent effect on the performance of skills tests. In many cases, there is an additional decrease in performance time after a lay-off. This could be due to the fact that some subjects participated in hockey schools during the summer. Any possible effects may also have been masked by the effect of growth.

On all variables but one (speed sit-ups), the superiority of the

competitive group began at the onset of the study and was maintained throughout the four year span. It would have been interesting if the study had begun at an earlier age with the competitive and control hockey teams being selected at that time.

Recommendations for Further Study

1. More work on the validity of the ice hockey skills tests of the present study is needed.
2. Longer studies beginning at an earlier age may answer many more questions as to the contribution of competitive hockey and summer activity to fitness levels.

Conclusions

From the results of the present study, some conclusions appear justified:

1. No effect on growth as measured by height and weight is apparent in the present study.
2. A selected group of hockey players who engage in an intense program of ice hockey are capable of demonstrating fitness levels which are equal or superior to any available in the literature.
3. The control group, although inferior to the competitive group, demonstrates fitness levels that are equal or superior to most other findings.
4. Male hockey players aged 8 to 11 who engage in an intense ice hockey program (60 - 70 games per year) are able to

demonstrate skill levels superior to other findings and to those of a control group that plays in a more recreational league (25 games per year) as measured by the battery of ice hockey skills tests of the present study.

5. Lay-offs have no apparent effect on the performance times of the ice hockey skills tests of the present study in boys 8 to 11 years of age.

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APPENDIX A

NAMES AND BIRTHDATES OF CONTROL AND COMPETITIVE GROUPS

CONTROL GROUP

NAME	DATE OF BIRTH (Day, Month, Year)
Blade, D.	27 - 10 - 65
Belke, B.	01 - 02 - 65
Belke, M.	01 - 02 - 65
Enns, R.	13 - 07 - 65
Kucher, N.	19 - 04 - 65
Martin, D.	09 - 04 - 65
Nahorniak, D.	28 - 07 - 65
Pawliuk, D.	06 - 05 - 65
Small, D.	23 - 08 - 65
Szaskiewicz, P.	30 - 10 - 65
Workum, J.	10 - 03 - 65
Yuen, L.	27 - 08 - 65
Spencer, G.	24 - 11 - 65
Wozniak, L.	03 - 09 - 65

COMPETITIVE GROUP

NAME	DATE OF BIRTH (Day, Month, Year)
Antoniuk, M.	12 - 01 - 65
Carlson, R.	11 - 06 - 65
Donadt, R.	26 - 03 - 65
Donald, S.	24 - 06 - 65
Holgate, B.	16 - 12 - 65
Jones, B.	06 - 09 - 65
Leisen, B.	13 - 07 - 65
Lund, G.	12 - 07 - 65
Lund, T.	12 - 07 - 65
Macnab, B.	16 - 07 - 65
Milligan, P.	21 - 04 - 65
Roberge, D.	15 - 02 - 65
Tkachuk, S.	25 - 02 - 65
Christensson, C.	31 - 08 - 65

APPENDIX B

CALIBRATION TABLE FOR

THE BICYCLE ERGOMETER

CALIBRATION TABLE FOR THE BICYCLE ERGOMETER

KP SETTING	CALIBRATION A*
0.5	.220
1.0	.415
1.5	.650
2.0	.870
2.5	1.080
3.0	1.290
3.5	1.540
4.0	1.745
4.5	1.960
5.0	2.250
5.5	2.440
6.0	2.650
6.5	2.870
7.0	3.070

N.B. In all PWC 170 tests a small modified pendulum was employed as described by Howell and Macnab (1967).

*ACTUAL KP - represents the number of grams required to raise the pendulum to successive scale markings.

APPENDIX C

COMPUTER PROGRAM FOR THE CALCULATION OF

PREDICTED MVO_2 AND PWC_{170}

COMPUTER PROGRAM FOR THE CALCULATION OF PREDICTED MVO_2 AND PWC_{170}

```
        ∇VO2M[0]∇
        ∇ VO2M
[1]     'CALCULATION OF VO2 MAX. AND PWC'
[2]     ''
[3]     'HEART RATE:'
[4]     HR←0
[5]     'WORK LOAD:'
[6]     WL←0
[7]     'CALIBRATION OF THE BICYCLE:'
[8]     CB←0
[9]     NWL←WLxCB
[10]    'AGE CORRECTION FACTOR:'
[11]    AG←0
[12]    'WEIGHT IN KG.'
[13]    WG←0
[14]    'SEXE,  0 IF WOMEN,  1 IF MEN:'
[15]    SX←0
[16]    →(SX=0)/20
[17]    BB←NWLx0.00237
[18]    VO←((195-61)xBB)÷(HR-61)
[19]    →21
[20]    VO←(198-72)xBB)÷(HR-72)
[21]    VO←VOxAG
[22]    NUM←NWL÷HR
[23]    PWC1←NUMx170
[24]    PWC2←NUMx160
[25]    PWC3←NUMx150
[26]    PWC4←NUMx140
[27]    PWC5←NUMx130
[28]    VOL←(VOx1000)÷WG
[29]    PWCK←PWC1÷WG
[30]    ''
[31]    'VO2 MAX (L./MIN.)'
[32]    VO
[33]    ''
[34]    'PWC 170'
[35]    PWC1
[36]    'PWC 160'
[37]    PWC2
[38]    'PWC 150'
[39]    PWC3
[40]    'PWC 140'
[41]    PWC4
[42]    'PWC 130'
[43]    PWC5
[44]    ''
[45]    'VO2 MAX (ML./KG./MIN.)'
[46]    VOL
[47]    'PWC 170 (KPM./KG./MIN.)'
[48]    PWCK
```

APPENDIX D

LEGEND OF HOCKEY SKILL TESTS

LEGEND

SUBJECT	S
CONE	x
FORWARD SKATING	→
JUMPING	
BACKWARD SKATING	
FINISH	F
RUNNING	

APPENDIX E

RAW SCORES

EXPERIMENTAL GROUP

TEST ITEM: Front Skating 60'

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	3.5	3.7	3.2	3.2	3.2	2.9	3.0	3.2
R. CARLSON	3.5	3.7	3.5	3.4	3.2	3.0	3.0	3.1
R. DONADT	3.6	3.4	3.5	3.1	2.8	2.7	2.7	3.0
S. DONALD	3.5	3.2	3.1	3.1	3.0	2.8	3.0	2.9
B. HOLGATE	3.6	3.5	3.3	3.1	3.1	3.0	3.0	3.4
B. JONES	3.7	3.5	3.3	3.0	2.8	2.9	3.1	2.8
B. LEISEN	3.3	3.4	3.2	3.1	3.0	2.8	2.9	3.0
G. LUND	3.5	3.5	3.2	3.4	3.3	2.9	2.8	2.8
T. LUND	3.7	3.7	3.5	3.3	3.3	3.1	3.0	3.3
B. MACNAB	3.6	4.0	3.2	3.1	2.9	2.9	2.6	2.5
P. MILLIGAN	3.7	4.0	3.5	3.6	3.1	3.0	2.9	3.1
G. PARKER	3.6*	3.6*	3.3*	3.2*	3.2	2.9	3.0	3.0
D. ROBERGE	3.2	3.2	3.1	3.2	2.9	3.0	2.9	2.8
S. TKACHUK	3.8	3.4	3.1	3.1	3.0	2.9	2.9	2.8
C. CHRISTENSON	3.7*	3.7*	3.4*	3.3*	3.2	2.9	3.3	3.0
MEANS	3.6	3.6	3.3	3.2	3.1	2.9	2.9	3.0
S.D.	.153	.232	.148	.154	.156	.096	.158	.219

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Front Skating 90'

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	5.0	5.1	4.6	4.3	4.4	4.1	4.4	4.3
R. CARLSON	5.0	5.1	5.2	4.6	4.9	4.3	4.5	4.3
R. DONADT	5.2	5.0	5.2	4.2	4.2	4.0	4.2	4.2
S. DONALD	4.9	4.5	4.7	4.5	4.6	4.1	4.4	4.0
B. HOLGATE	5.2	5.0	5.3	4.4	4.6	4.3	4.4	4.5
B. JONES	5.5	4.7	4.7	4.3	4.3	4.1	4.5	4.1
B. LEISEN	5.0	5.3	5.5	4.5	4.7	4.0	4.4	4.3
G. LUND	4.8	4.6	4.8	4.5	4.6	4.3	4.4	4.2
T. LUND	5.0	4.9	5.1	4.7	4.9	4.5	4.5	4.5
B. MACNAB	5.1	5.4	4.7	4.3	4.7	4.1	4.6	4.0
P. MILLIGAN	5.1	5.4	4.9	4.7	4.7	4.3	4.5	4.4
G. PARKER	5.0*	4.9*	4.8*	4.4*	4.6	4.2	4.3	4.2
D. ROBERGE	4.6	4.7	4.8	4.6	4.4	4.2	4.3	3.9
S. TKACHUK	5.4	4.9	4.8	4.4	4.5	4.2	4.4	4.0
C. CHRISTENSON	5.1*	5.0*	4.9*	4.5*	4.8	4.3	4.4	4.4
MEANS	5.1	5.0	4.9	4.5	4.6	4.2	4.4	4.2
S.D.	.212	.262	.255	.145	.198	.132	.094	.183

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Front Skating 120'

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	6.5	6.6	6.1	5.7	5.7	5.3	5.6	5.6
R. CARLSON	6.5	6.6	6.8	6.0	5.4	4.6	5.8	5.7
R. DONADT	6.5	6.5	6.5	5.5	5.3	5.2	5.4	5.5
S. DONALD	6.4	6.3	6.6	5.8	5.5	5.3	5.5	5.5
B. HOLGATE	7.0	6.7	6.6	5.8	5.3	5.7	5.9	6.1
B. JONES	7.0	6.6	6.3	5.6	5.4	5.4	5.6	5.5
B. LEISEN	6.5	6.8	6.7	5.7	5.5	5.3	5.5	5.5
G. LUND	6.5	6.1	6.2	5.9	5.5	5.6	5.6	5.7
T. LUND	6.7	6.8	6.7	6.2	5.4	5.8	5.9	6.1
B. MACNAB	6.8	6.9	6.3	5.8	5.5	5.6	5.6	5.0
P. MILLIGAN	6.6	6.9	6.6	5.9	5.5	5.6	6.0	5.9
G. PARKER	6.7*	6.7*	6.5*	5.9*	5.8	5.5	5.5	5.7
D. ROBERGE	6.6	6.4	6.0	5.7	5.7	5.4	5.5	5.2
S. TKACHUK	6.6	6.0	6.2	5.7	5.7	5.3	5.6	5.5
C. CHRISTENSON	6.6*	6.6*	6.4*	5.8*	5.9	5.4	5.3	5.6
MEANS	6.6	6.6	6.4	5.8	5.5	5.4	5.6	5.6
S.D.	.174	.259	.233	.163	.174	.276	.190	.282

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Back Skating 60'

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	Post	1974-75 Pre	Post	1975-76 Pre	Post	1976-77 Pre	Post
M. ANTONIUK	4.8	5.0	4.2	4.0	4.0	3.9	3.5	4.0
R. CARLSON	4.8	5.0	5.0	4.6	4.7	3.8	3.7	3.6
R. DONADT	5.2	5.2	4.7	4.3	4.1	3.7	3.6	3.9
S. DONALD	5.8	5.5	4.9	4.5	4.3	4.1	4.2	4.2
B. HOLGATE	6.0	5.8	5.0	4.2	4.1	4.0	3.8	4.0
B. JONES	6.0	6.0	5.4	5.2	4.6	4.1	4.2	4.8
B. LEISEN	7.9	7.2	4.5	4.5	4.3	4.0	3.6	3.5
G. LUND	5.0	5.2	4.6	4.7	4.4	4.4	3.5	3.6
T. LUND	4.9	5.3	4.5	4.2	4.1	4.1	4.1	4.2
B. MACNAB	5.9	5.0	5.1	4.6	4.1	4.0	3.7	3.8
P. MILLIGAN	6.4	5.5	5.0	4.9	4.7	4.8	4.7	4.3
G. PARKER	6.0*	5.9*	5.0*	4.8*	5.1	4.5	4.0	3.8
D. ROBERGE	5.2	5.4	4.5	4.1	4.6	3.9	4.4	4.0
S. TKACHUK	6.0	5.2	4.2	4.2	4.1	4.2	4.1	3.7
C. CHRISTENSON	6.1*	6.0*	5.1*	4.9*	4.8	4.3	4.6	4.0
MEANS	5.7	5.6	4.8	4.5	4.4	4.1	4.0	4.0
S.D.	.780	.549	.341	.334	.320	.276	.378	.320

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Back Skating 90'

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	6.8	6.9	4.3	5.5	5.8	5.5	5.7	5.5
R. CARLSON	6.8	6.9	7.1	6.2	6.8	5.4	5.5	5.7
R. DONADT	7.5	7.6	6.9	6.0	5.8	5.6	5.5	5.7
S. DONALD	8.2	7.6	7.2	6.7	6.5	5.8	6.1	6.1
B. HOLGATE	8.6	7.4	7.2	5.4	6.0	5.7	5.5	5.8
B. JONES	8.8	8.7	8.1	7.0	6.7	6.1	6.1	6.5
B. LEISEN	10.8	9.5	6.4	6.2	6.6	5.8	4.2	4.9
G. LUND	7.1	7.1	7.0	6.5	6.5	5.9	5.4	5.6
T. LUND	7.0	7.4	6.7	6.0	6.0	5.7	6.0	6.0
B. MACNAB	8.4	8.4	7.6	6.3	6.1	5.9	5.5	5.5
P. MILLIGAN	8.7	9.1	7.5	7.0	7.1	6.8	6.5	6.4
G. PARKER	8.2*	8.0*	6.8*	6.3*	6.8	6.3	5.9	5.2
D. ROBERGE	8.2	7.6	6.5	5.8	6.6	5.6	6.2	5.6
S. TKACHUK	8.4	8.0	5.9	5.9	6.2	6.0	6.0	5.4
C. CHRISTENSON	8.3*	8.1*	7.0*	6.4*	6.5	6.6	6.0	5.5
MEANS	8.1	7.9	6.8	6.2	6.4	5.9	5.7	5.7
S.D.	.986	.746	.847	.457	.381	.383	.516	.409

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Back Skating 120'

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	9.1	9.0	8.2	7.3	7.6	7.3	7.2	7.0
R. CARLSON	9.0	9.0	9.5	8.2	8.3	7.1	7.3	7.3
R. DONADT	9.8	10.2	9.2	8.0	7.2	7.1	7.1	7.2
S. DONALD	10.6	10.3	9.2	8.6	7.5	7.6	7.9	7.8
B. HOLGATE	12.2	10.9	9.6	7.7	7.5	7.4	7.2	7.6
B. JONES	11.4	11.3	10.4	9.0	7.5	7.9	7.9	8.5
B. LEISEN	12.5	11.5	8.7	8.1	8.1	7.2	6.7	6.8
G. LUND	9.4	9.6	9.3	8.4	8.0	7.8	7.5	7.5
T. LUND	9.0	10.0	8.7	7.7	7.6	7.3	7.6	7.7
B. MACNAB	10.9	11.2	9.9	8.3	7.7	7.7	7.1	7.3
P. MILLIGAN	11.9	10.8	9.9	8.9	8.9	8.9	8.4	8.5
G. PARKER	10.6*	10.4*	9.3*	8.2*	8.4	7.9	7.4	7.3
D. ROBERGE	10.3	10.1	8.5	7.4	8.6	7.3	8.0	7.0
S. TKACHUK	11.0	9.8	7.8	7.6	7.4	7.5	7.5	7.3
C. CHRISTENSON	10.7*	10.5*	9.4*	8.3*	8.5	7.8	7.7	7.3
MEANS	10.6	10.3	9.2	8.6	7.9	7.6	7.5	7.5
S.D.	1.10	.738	.667	.489	.499	.443	.418	.477

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Agility Skating

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	13.7	13.2	11.3	11.2	10.5	10.3	9.6	9.0
R. CARLSON	13.7	13.2	12.2	10.9	12.2	10.0	9.7	9.2
R. DONADT	13.2	13.0	11.9	10.9	11.9	10.0	10.0	9.6
S. DONALD	13.6	13.5	13.3	11.6	12.6	10.7	10.8	9.6
B. HOLGATE	15.9	13.9	12.6	11.5	11.4	10.6	10.6	10.7
B. JONES	14.5	12.8	12.9	12.1	13.0	11.1	10.9	10.9
B. LEISEN	12.5	11.5	11.3	11.2	12.0	10.3	10.0	10.4
G. LUND	13.6	12.5	13.0	11.0	11.5	10.1	9.9	10.1
T. LUND	12.7	12.8	12.5	11.0	11.2	10.1	10.0	9.4
B. MACNAB	14.0	12.7	11.4	10.8	11.1	9.9	10.0	9.5
P. MILLIGAN	14.9	12.7	13.2	11.7	12.7	10.8	11.0	10.4
G. PARKER	13.6*	12.5*	12.0*	11.0*	10.7	10.5	10.2	10.1
D. ROBERGE	13.1	11.7	11.9	10.8	11.9	9.9	10.5	10.0
S. TKACHUK	13.6	12.0	10.8	10.6	11.8	9.8	10.2	10.0
C. CHRISTENSON	14.1*	13.0*	12.5*	11.5*	11.7	11.1	10.9	9.9
MEANS	13.8	12.7	12.2	11.2	11.7	10.3	10.3	9.9
S.D.	.823	.620	.736	.398	.687	.418	.446	.524

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Puck Control - Marcotte Modified

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	17.4	20.6	15.5	16.6	19.9	13.5	13.9	13.2
R. CARLSON	17.4	20.6	18.1	16.7	17.9	15.6	14.4	15.5
R. DONADT	18.4	18.5	17.3	15.1	15.6	15.4	13.9	15.8
S. DONALD	21.6	20.1	17.7	16.1	17.6	15.5	14.6	14.9
B. HOLGATE	21.8	19.3	18.5	16.0	16.6	14.8	15.0	15.7
B. JONES	20.7	18.9	19.4	17.1	17.0	15.9	15.8	15.4
B. LEISEN	17.9	17.7	16.7	16.6	16.4	15.2	13.4	14.0
G. LUND	17.7	17.1	17.0	15.7	16.5	14.9	14.3	14.9
T. LUND	18.4	18.7	17.3	16.4	15.6	16.5	14.3	14.0
B. MACNAB	19.6	17.0	15.4	14.9	15.4	14.2	14.2	13.9
P. MILLIGAN	20.5	19.5	17.2	18.0	16.4	15.6	15.3	15.4
G. PARKER	19.3*	18.9*	17.3*	16.3	18.0	14.8	14.6	14.5
D. ROBERGE	18.5	18.9	16.7	15.7	15.7	15.0	14.3	15.1
S. TKACHUK	20.0	18.0	17.0	15.8	16.6	14.4	14.8	15.5
C. CHRISTENSON	20.2*	19.8*	18.2*	17.2*	19.0	16.4	14.8	15.4
MEANS	19.3	18.9	17.3	16.3	16.9	15.2	14.5	14.9
S.D.	1.42	1.09	1.01	.782	1.27	.776	.573	.767

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Puck Control - Hansen

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK			22.9	19.9	18.0	16.8	16.9	18.0
R. CARLSON			24.0	20.5	22.0	18.7	18.0	19.5
R. DONADT			22.5	19.4	19.8	22.5	19.4	19.6
S. DONALD			26.2	24.3	23.5	21.5	19.0	19.4
B. HOLGATE			23.9	23.3	22.0	19.0	18.8	20.0
B. JONES			27.9	23.7	21.5	19.3	20.4	20.0
B. LEISEN			22.4	20.3	22.6	19.4	18.3	19.2
G. LUND			25.1	20.4	20.4	17.9	17.9	18.2
T. LUND			29.8	20.5	21.5	19.8	20.7	19.2
B. MACNAB			23.5	22.4	20.6	18.6	17.3	17.5
P. MILLIGAN			25.9	22.3	21.2	19.2	18.9	19.0
G. PARKER			25.0*	21.7*	23.4	20.3	18.9	17.8
D. ROBERGE			25.5	22.0	20.7	19.0	18.7	17.6
S. TKACHUK			22.9	20.7	21.7	18.5	20.0	18.6
C. CHRISTENSON			28.1*	24.8*	29.3	21.4	20.9	20.8
MEANS			25.0	21.7	21.9	19.5	18.9	19.0
S.D.			2.16	1.63	2.39	1.42	1.42	.949

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Backward Agility Skating

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK				11.4	10.2	8.4	10.0	10.0
R. CARLSON				11.6	11.6	8.6	9.5	8.3°
R. DONADT				12.0	10.9	9.0	10.6	8.4°
S. DONALD				12.8	11.9	9.4	11.0	9.0°
B. HOLGATE				12.9	11.2	9.4	11.7	9.4
B. JONES				19.9	11.7	9.7	11.0	10.1°
B. LEISEN				12.5	11.1	9.0	9.8	8.5°
G. LUND				12.7	10.8	9.0	10.0	8.5
T. LUND				11.5	11.0	8.8	10.6	8.3
B. MACNAB				11.4	10.2	8.6	10.0	7.6
P. MILLIGAN				13.9	11.0	9.9	11.6	10.0
G. PARKER				13.2*	11.9	9.7	10.7	8.9
D. ROBERGE				12.1	11.2	9.3	11.3	8.2
S. TKACHUK				11.9	11.0	9.0	9.9	8.5°
C. CHRISTENSON				13.4*	12.5	9.0	11.0	9.6
MEANS				12.9	11.2	9.1	10.6	8.9
S.D.				2.02	.603	.425	.664	.741

* Estimated values according to method outlined in Chapter III.

° Corrections made for Backward Agility Skating according to method outlined in Chapter III.

TEST ITEM: Shuttle Run

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	12.9	12.2		12.3		11.4		11.5
R. CARLSON	12.3	11.9		11.6		11.1		11.5
R. DONADT	12.2	11.4		11.0		11.8		11.3
S. DONALD	12.9	11.5		11.9		11.7		12.0
B. HOLGATE	14.5	12.4		11.8		11.7		11.4
B. JONES	13.0	12.4		12.5		12.4		11.5
B. LEISEN	12.6	11.6		12.4		11.2		11.4
G. LUND	13.2	11.8		11.4		11.2		11.6
T. LUND	12.6	11.2		11.1		11.5		12.2
B. MACNAB	13.1	12.8		12.0		12.8		11.2
P. MILLIGAN	13.0	11.8		12.3		12.3		11.1
G. PARKER	12.5*	11.3*		11.3*		11.4		10.7
D. ROBERGE	12.2	11.4		11		11.0		12.0
S. TKACHUK	15.0	11.6		11.8		11.7		13.1
C. CHRISTENSON	12.9*	11.7*		11.7*		12.0		11.1
MEANS	13.0	11.8		11.7		11.7		11.6
S.D.	.760	.447		.488		.498		.553

* Estimated values according to method outlined in Chapter III.

TEST ITEM: 50 Yards

Recorded in Seconds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	9.2	9.0		8.4		8.0		7.6
R. CARLSON	9.0	8.6		8.0		7.8		7.6
R. DONADT	8.6	8.5		8.4		7.8		7.5
S. DONALD	9.1	8.4		7.4		7.6		7.8
B. HOLGATE	8.9	8.8		8.0		7.6		7.6
B. JONES	8.7	8.5		7.9		7.7		7.8
B. LEISEN	8.9	8.8		9.3		8.2		8.4
G. LUND	8.9	8.9		8.3		7.8		8.1
T. LUND	9.4	9.0		8.7		7.9		8.4
B. MACNAB	9.1	8.8		7.9		7.4		7.4
P. MILLIGAN	9.0	10.5		8.0		7.8		8.3
G. PARKER	8.8*	8.6*		8.0*		7.5		7.8
D. ROBERGE	8.2	8.3		7.9		7.4		7.6
S. TKACHUK	9.6	8.9		8.5		8.0		8.6
C. CHRISTENSON	9.2*	9.0*		8.4*		8.2		7.8
MEANS	9.0	8.8		8.2		7.8		7.9
S.D.	.323	.541		.428		.245		.365

* Estimated values according to method outlined in Chapter III.

TEST ITEMS: 300 Yards

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	67.4	65.5		64		60.0		62.4
R. CARLSON	66.5	65.5		62.5		60.8		58.5
R. DONADT	67.7	65.5		63.5		64.1		61.0
S. DONALD	68.7	66.0		62.5		58.2		59.5
B. HOLGATE	70.9	66.4		66.0		61.0		60.0
B. JONES	68.5	70.0		67.0		67.8		63.6
B. LEISEN	73.6	71.5		66.0		65.8		67.4
G. LUND	72.0	71.5		66.0		61.2		65.3
T. LUND	71.3	71.0		65.5		63.5		66.0
B. MACNAB	70	66		64		62.6		59.5
P. MILLIGAN	71.8	73.0		68.0		62.6		62.9
G. PARKER	67.7*	66.0*		60.4*		58.5		61.5
D. ROBERGE	63.2	65.4		63.0		59.3		60.4
S. TKACHUK	81.9	74.0		65.0		67.2		68.0
C. CHRISTENSON	72.6*	70.9*		67.1*		67.7		62.0
MEANS	70.2	68.5		64.7		62.7		62.5
S.D.	4.08	3.08		2.02		3.15		2.87

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Standing Broad Jump

Recorded in Inches

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	Post	1974-75 Pre	Post	1975-76 Pre	Post	1976-77 Pre	Post
M. ANTONIUK	57.2	58.1		63.0		72.5		75
R. CARLSON	57.3	59.5		57		68.0		66
R. DONADT	57.7	52.2		70.0		74.0		67.2
S. DONALD	61.2	56.6		56		63		70
B. HOLGATE	60.0	56.1		64.0		72.0		67.0
B. JONES	56.0	49.7		59.0		63.5		68
B. LEISEN	51.2	58.0		60		62		67.5
G. LUND	52.7	60.0		57.5		64.5		64.0
T. LUND	57.7	60.2		56.5		65		59.5
B. MACNAB	52.2	54.0		64.5		64.5		71.5
P. MILLIGAN	51	48		52		63		65
G. PARKER	57.3*	66.1*		62.0*		69.5	67	
D. ROBERGE	62	62.8		69		67.5		71.5
S. TKACHUK	56.2	53.7		64		65		65
C. CHRISTENSON	59.5*	59.3*		64.2*		65		76
MEANS	56.6	57.0		61.2		66.6		68.0
S.D.	3.36	4.67		4.82		3.68		3.98

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Flex Arm Hang

Recorded in Seconds

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	45	63		75		78		84
R. CARLSON	74	60		133		70		70.5
R. DONADT	45	61		70		70		44
S. DONALD	40	64		87		64		68.5
B. HOLGATE	37	80		74		86.0		68.0
B. JONES	21	25		46		70.0		57.0
B. LEISEN	17	33		62		26		20.0
G. LUND	35	74		11.4		83		60.5
T. LUND	72	68		111		87		92.5
B. MACNAB	61	72		99		84		91.5
P. MILLIGAN	22	13		47		52		39.0
G. PARKER	18.3*	34.3*		46.7*		45		53.5
D. ROBERGE	50	60		59.5		59		22.5
S. TKACHUK	20	75		33.5		33		32.0
C. CHRISTENSON	34.8*	50.8*		63.2*		45		70.0
MEANS	39.5	55.5		67.9		63.5		58.2
S.D.	18.1	19.4		29.9		18.9		22.3

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Sit Ups

Recorded in Number

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	36	26		45		52		57
R. CARLSON	30	29		35		54		46
R. DONADT	35	36		42		64		72
S. DONALD	28	17		33		45		44
B. HOLGATE	31	22		32		47		50
B. JONES	34	26		44		42		46
B. LEISEN	32	29		30		43		53
G. LUND	37	35		46		46		50
T. LUND	37	39		45		49		48
B. MACNAB	40	39		47		43		54
P. MILLIGAN	22	10		31		54		51
G. PARKER	33.5*	29.6*		40.1		46		53
D. ROBERGE	42	42		46		48		52
S. TKACHUK	28	31		41		43		43
C. CHRISTENSON	24.5*	20.6*		31.1		36		45
MEANS	32.7	28.7		39.2		47.5		50.9
S.D.	5.37	8.56		6.22		6.39		6.85

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Grip Strength (Left)

Recorded in Kg

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	24.7	27.2		28.7		25		32.5
R. CARLSON	18.8	19.8		20.3		20		24.5
R. DONADT	18.2	20.3		17.8		19		31
S. DONALD	21.8	26.2		24		26		33
B. HOLGATE	14.8	20.3		19.3		20		33.0
B. JONES	17.8	16.8		17.3		19		21
B. LEISEN	17.8	17.8		22.8		18		25
G. LUND	15.4	15.8		15.3		19		23
T. LUND	13.3	15.8		13.4		16		20.5
B. MACNAB	16.8	17.3		18.8		16.0		25
P. MILLIGAN	18.8	20.3		16.8		22		28
G. PARKER	18.2*	20.0*		19.9*		21		26.5
D. ROBERGE	16.8	19.3		15.8		18		22.5
S. TKACHUK	14.9	16.8		21.8		22		24
C. CHRISTENSON	18.0*	19.8*		19.7*		21		26
MEANS	17.7	19.6		19.4		20.1		26.4
S.D.	2.72	3.23		3.71		2.75		4.10

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Grip Strength (Right)

Recorded in Kg

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	Post	1974-75 Pre	Post	1975-76 Pre	Post	1976-77 Pre	Post
M. ANTONIUK	26.2	27.2		29.8		23		31.0
R. CARLSON	17.8	18.3		19.8		22		28.0
R. DONADT	18.8	21.8		22.3		22		32.5
S. DONALD	24.7	23.2		26		26		37
B. HOLGATE	14.8	19.8		19.3		21		28.0
B. JONES	15.8	16.3		18.8		20		24
B. LEISEN	17.3	17.3		22.8		19		28
G. LUND	16.3	16.3		16.8		19		23
T. LUND	17.3	18.3		15.8		19		23
B. MACNAB	15.8	17.3		21.8		18.0		25
P. MILLIGAN	17.8	18.3		14.8		20		28
G. PARKER	18.1*	19.3*		20.5*		21		28
D. ROBERGE	17.3	18.8		17.8		20		24.0
S. TKACHUK	13.8	16.8		21.8		25		28
C. CHRISTENSON	20.4*	21.6*		23.0*		24		31
MEANS	18.1	19.4		20.7		21.3		27.9
S.D.	3.27	2.89		3.77		2.29		3.87

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Height

Recorded in Cm

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	142.2	142.2		146.0		153.1		158.7
R. CARLSON	131.3	133.1		137.8		145.5		151.1
R. DONADT	133.3	134.6		137.1		143.5		149.2
S. DONALD	138.9	140.2		144.7		152.4		163.8
B. HOLGATE	133.8	133.8		138.4		142.5		149.2
B. JONES	132.0	133.8		138.4		143.5		149.8
B. LEISEN	139.7	142.7		145.4		153.6		158.7
G. LUND	129.5	130.8		135.9		139.9		146.0
T. LUND	128.2	129.5		133.8		137.1		142.9
B. MACNAB	130.0	132.6		132.7		139.7		147.9
P. MILLIGAN	131.3	131.3		134.6		139.7		143.1
G. PARKER	135.2*	136.3*		140.0*		147.32		152.4
D. ROBERGE	125.7	128.2		134.6		138.4		143.5
S. TKACHUK	126.2	128.3		131.4		138.4		144.8
C. CHRISTENSON	134.1*	135.4*		139.2*		144.7		153.4
MEANS	132.3	134.1		137.9		143.6		149.9
S.D.	4.79	4.44		4.53		5.34		6.05

* Estimated values according to method outlined in Chapter III.

TEST ITEM: PWC/170/Kg

Recorded in Kpm/Kg/min

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	15.23	15.97		13.29		11.39		14.7
R. CARLSON	15.15	16.73		15.33		15.43		16.5
R. DONADT	13.64	16.29		14.49		17.19		15.87
S. DONALD	12.8	12.8		13.0		12.56		12.48
B. HOLGATE	16.0	18.1		15.4		16.2		14.5
B. JONES	12.1	11.8		14.1		16.6		13.8
B. LEISEN	11.7	12.2		11.6		13.3		11.71
G. LUND	17.2	19.1		17.4		16.3		18.7
T. LUND	17.2	18.3		19.0		18.2		19.0
B. MACNAB	15.9	16.7		16.2		16.4		17.7
P. MILLIGAN	13.3	13.6		15.7		13.7		17.0
G. PARKER	15.9*	16.7*		16.1*		17.2		18.2
D. ROBERGE	15.8	14.3		14.5		18.3		19.9
S. TKACHUK	14.3	14.4		15.0		17.0		17.7
C. CHRISTENSON	13.2*	10.9*		10.8*		9.13		14.3
MEANS	14.6	15.2		14.8		15.3		16.1
S.D.	1.70	2.46		2.03		2.58		2.39

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Weight

Recorded in Pounds

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	74.0	77.5		86.0		94.9		103.5
R. CARLSON	57.0	59.0		65.0		73.1		81.0
R. DONADT	57.1	65.0		66.7		73.6		87.0
S. DONALD	72.0	75.0		81.0		94.2		108.0
B. HOLGATE	54.5	57.0		61.0		66.0		78.0
B. JONES	59.5	61.5		68.0		69.2		87.2
B. LEISEN	71.5	74.0		83.0		86.6		102.0
G. LUND	54.5	56.4		60.0		67.1		75.0
T. LUND	52.0	53.5		56.2		61.0		68.5
B. MACNAB	54.0	58.0		61.7		58.7		76.5
P. MILLIGAN	60.0	59.0		63.0		70.1		78.0
G. PARKER	61.3*	64.0*		69.4*		77.7		85.0
D. ROBERGE	55.0	57.0		64.0		67.2		75.5
S. TKACHUK	55.0	58.0		65.5		76.7		86.0
C. CHRISTENSON	62.9*	65.6*		71.0*		78.7		87.2
MEANS	60.0	62.7		68.1		74.3		85.2
S.D.	6.88	7.19		8.48		10.5		11.0

* Estimated values according to method outlined in Chapter III.

TEST ITEM: PWC_{170}

Recorded in Kpm/min

EXPERIMENTAL
GROUP

SUBJECT	1973-74 Pre	Post	1974-75 Pre	Post	1975-76 Pre	Post	1976-77 Pre	Post
M. ANTONIUK	512	563		520		487		685
R. CARLSON	393	449		453		508		601.6
R. DONADT	356	452		440		570		622.0
S. DONALD	420	437		479		533.3		607.3
B. HOLGATE	394	471		425		483		509.2
B. JONES	327	332		436		569		545.6
B. LEISEN	382	412		437		519		538.1
G. LUND	424	510		475		493		632
T. LUND	407	459		487		501.1		587.7
B. MACNAB	392	441		457		435		611
P. MILLIGAN	365	365		450		435.3		596.8
G. PARKER	444.2	484.2		506.1		516.9		695
D. ROBERGE	395	373		422		554		678
S. TKACHUK	357	380		448		588		685
C. CHRISTENSON	284.6	324.7		346.6		329.8		563.1
MEANS	390.2	430.2		452.1		501.5		610.5
S.D.	50.5	64.1		39.5		63.2		55.8

* Estimated values according to method outlined in Chapter III.

TEST ITEM: Predicted MVO_2

Recorded in ml/Kg/min

EXPERIMENTAL GROUP

SUBJECT	1973-74 Pre	1973-74 Post	1974-75 Pre	1974-75 Post	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
M. ANTONIUK	48.9	51.3		42.7		36.2		46.7
R. CARLSON	48.7	53.8		49.2		49.1		52.5
R. DONADT	44.0	49.1		46.6		54.7		50.5
S. DONALD	41.2	41.2		41.8		39.9		39.7
B. HOLGATE	51.1	58.4		49.2		51.7		46.1
B. JONES	38.8	38.1		45.3		58.1		44.2
B. LEISEN	37.7	39.3		37.2		42.3		37.3
G. LUND	54.9	63.9		55.9		51.9		59.5
T. LUND	55.3	60.6		61.2		58.0		60.6
B. MACNAB	51.3	53.7		52.3		52.3		56.4
P. MILLIGAN	42.9	43.7		50.5		43.8		54.1
G. PARKER	51.2	53.4		51.5		47.0		57.7
D. ROBERGE	50.7	46.2		46.6		58.2		63.4
S. TKACHUK	45.8	46.3		48.3		54.1		56.3
C. CHRISTENSON	31.9	34.9		34.5		29.6		45.6
MEANS	46.3	48.9		47.6		48.5		51.4
S.D.	6.53	8.29		6.67		8.28		7.59

* Estimated values according to method outlined in Chapter III.

APPENDIX F

RAW SCORES

CONTROL GROUP

TEST ITEM: Front Skating 60'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	3.4	3.2	3.4	2.8
B. BELKE	3.2	3.0	3.6	3.5
M. BELKE	3.5	3.0	3.2	3.4
R. ENNS	3.1	3.0	3.5	3.0
N. KUCHER	3.4	2.9	3.5	2.6
D. MARTIN	3.6	3.0	3.5	2.9
D. NAHORNIAK	3.6	3.0	3.1	3.8
D. PAWLUK	3.2	3.0	3.5	3.0
D. SMALL	3.4	3.0	3.0	3.3
P. SZASZKIEWICZ°			3.2	3.2
J. WORKUM	3.4	2.9	3.4	3.0
L. YUEN	4.0	3.3	3.3	3.2
G. SPENCER °				3.0
MEANS	3.4	3.0	3.4	3.1
S.D.	.235	.114	.182	.328

° Excluded from analysis.

TEST ITEM: Front Skating 90'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	4.9	4.6	4.6	4.4
B. BELKE	4.7	4.4	4.6	4.5
M. BELKE	4.7	4.2	4.6	4.6
R. ENNS	5.0	4.4	4.8	4.2
N. KUCHER	4.5	4.3	4.4	4.2
D. MARTIN	5.0	4.3	4.6	4.4
D. NAHORNIAK	5.0	4.5	4.6	5.5
D. PAWLUK	4.2	4.4	4.8	4.3
D. SMALL	5.0	4.3	4.5	4.3
P. SZASZKIEWICZ°			4.6	4.2
J. WORKUM	4.8	4.2	4.4	4.2
L. YUEN	5.4	4.8	4.5	4.4
G. SPENCER °				4.2
MEANS	4.8	4.4	4.6	4.5
S.D.	.299	.171	.127	.353

° Excluded from analysis.

TEST ITEM: Front Skating 120'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	6.0	5.6	5.5	5.8
B. BELKE	5.8	5.7	5.6	5.9
M. BELKE	6.0	5.6	5.6	5.8
R. ENNS	6.2	5.7	5.5	5.4
N. KUCHER	6.0	5.7	5.5	5.3
D. MARTIN	6.2	5.6	5.6	5.6
D. NAHORNIAK	6.9	5.7	6.2	7.0
D. PAWLUK	6.0	5.7	5.6	5.7
D. SMALL	6.5	5.5	6.5	5.5
P. SZASZKIEWICZ°			5.3	5.4
J. WORKUM	5.9	5.4	5.3	5.4
L. YUEN	6.8	6.1	5.8	5.5
G. SPENCER °				5.6
MEANS	6.2	5.7	5.7	5.7
S.D.	.350	.167	.333	.445

° Excluded from analysis.

TEST ITEM: Back Skating 60'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	5.6	4.6	5.0	4.8
B. BELKE	4.9	4.6	4.6	4.4
M. BELKE	5.5	4.7	4.5	4.9
R. ENNS	5.0	4.0	4.5	4.1
N. KUCHER	4.5	4.7	4.9	4.0
D. MARTIN	6.4	4.6	5.3	4.5
D. NAHORNIAK	7.0	5.1	3.9	5.8
D. PAWLUK	4.9	4.4	4.9	4.4
D. SMALL	4.8	4.4	4.5	4.5
P. SZASZKIEWICZ°			5.7	4.7
J. WORKUM	5.3	4.3	4.6	4.6
L. YUEN	7.4	5.1	5.5	4.7
G. SPENCER °				4.6
MEANS	5.6	4.6	4.7	4.6
S.D.	.911	.309	.419	.456

° Excluded from analysis.

TEST ITEM: Back Skating 90'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	7.4	6.5	6.6	6.8
B. BELKE	6.8	6.6	6.1	6.1
M. BELKE	7.4	6.6	6.2	6.5
R. ENNS	7.4	5.7	6.0	5.6
N. KUCHER	6.1	6.7	6.5	5.8
D. MARTIN	9.1	6.4	7.2	6.1
D. NAHORNIAK	10.1	7.2	5.8	8.1
D. PAWLUK	7.0	6.4	6.5	6.4
D. SMALL	7.4	6.1	6.4	5.6
P. SZASZKIEWICZ°			7.1	6.4
J. WORKUM	7.4	6.0	6.3	6.0
L. YUEN	10.7	7.5	7.3	6.6
G. SPENCER °				6.4
MEANS	7.9	6.5	6.4	6.3
S.D.	1.37	.488	.442	.676

° Excluded from analysis.

TEST ITEM: Back Skating 120'

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	9.3	8.4	8.4	8.5
B. BELKE	8.9	8.5	7.8	7.6
M. BELKE	9.1	8.4	8.3	8.5
R. ENNS	9.1	7.6	7.7	6.8
N. KUCHER	8.0	8.7	8.7	7.4
D. MARTIN	11.9	8.6	9.3	7.8
D. NAHORNIAK	13.0	9.5	7.3	10.5
D. PAWLUK	9.1	8.3	8.3	8.2
D. SMALL	9.5	7.9	7.0	7.6
P. SZASZKIEWICZ°			9.0	8.0
J. WORKUM	9.4	8.0	8.2	7.7
L. YUEN	14.9	9.6	8.9	8.4
G. SPENCER °				8.1
MEANS	10.2	8.5	8.2	8.1
S.D.	2.02	.583	.651	.909

° Excluded from analysis.

TEST ITEM: Agility Skating

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	11.9	11.3	12.4	13.0
B. BELKE	13.4	12.7	11.7	10.0
M. BELKE	12.6	11.9	11.3	9.6
R. ENNS	12.5	11.9	12.6	10.0
N. KUCHER	12.9	12.2	12.2	11.0
D. MARTIN	12.8	12.1	11.5	12.5
D. NAHORNIAK	15.2	14.4	13.5	13.6
D. PAWLUK	11.5	10.9	12.1	11.6
D. SMALL	12.4	11.6	12.0	11.6
P. SZASZKIEWICZ°			12.9	10.1
J. WORKUM	13.5	12.8	11.0	11.0
L. YUEN	15.4	14.6	12.3	10.0
G. SPENCER °				10.0
MEANS	13.1	12.4	12.1	11.3
S.D.	1.18	1.12	.654	1.28

° Excluded from analysis.

TEST ITEM: Puck Control - Marcotte Modified

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	17.4	16.6	16.5	18.5
B. BELKE	19.2	18.5	17.4	15.7
M. BELKE	16.8	16.5	16.0	15.0
R. ENNS	18.5	17.3	18.0	16.1
N. KUCHER	19.6	17.0	16.5	16.0
D. MARTIN	19.0	17.0	16.8	16.9
D. NAHORNIAK	20.8	17.9	17.0	19.3
D. PAWLUK	17.9	16.2	16.3	16.6
D. SMALL	19.7	17.3	16.2	17.0
P. SZASZKIEWICZ°			16.7	14.6
J. WORKUM	19.5	17.5	15.8	17.7
L. YUEN	23.0	18.8	18.0	14.9
G. SPENCER °				14.6
MEANS	19.2	17.3	16.8	16.7
S.D.	1.62	.775	.719	1.32

° Excluded from analysis.

TEST ITEM: Puck Control - Hansen

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	31.2	22.7	23.1	22.7
B. BELKE	23.5	22.1	24.1	20.3
M. BELKE	22.5	21.5	22.2	22.3
R. ENNS	24.4	23.2	23.5	21.3
N. KUCHER	23.2	21.0	25.3	20.5
D. MARTIN	25.5	22.1	20.0	20.0
D. NAHORNIAK	28.5	20.3	14.0	20.8
D. PAWLUK	20.6	21.2	23.4	22.4
D. SMALL	29.5	23.7	25.5	21.5
P. SZASZKIEWICZ°			24.6	19.0
J. WORKUM	26.8	22.5	21.8	20.5
L. YUEN	29.0	25.0	25.7	20.8
G. SPENCER °				18.8
MEANS	25.9	22.3	22.6	21.2
S.D.	3.21	1.28	3.17	.882

° Excluded from analysis.

TEST ITEM: Backward Agility Skating

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE	13.9	10.3	14.2	10.9
B. BELKE	16.1	10.5	11.7	11.6
M. BELKE	14.4	10.4	12.5	9.7
R. ENNS	15.0	11.8	14.0	10.0
N. KUCHER	12.7	11.3	13.3	10.3
D. MARTIN	14.1	10.3	12.9	10.7
D. NAHORNIAK	19.9	13.5	16.0	13.3
D. PAWLUK	13.5	10.9	14.8	9.9
D. SMALL	12.6	10.2	13.4	8.6
P. SZASZKIEWICZ°			13.2	10.4
J. WORKUM	13.5	10.4	12.0	10.0
L. YUEN	19.6	14.0	15.0	10.1
G. SPENCER °				9.0
MEANS	15.0	11.2	13.6	9.6
S.D.	2.42	1.29	1.27	1.15

° Excluded from analysis.

TEST ITEM: Weight

Recorded in Pounds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		69.1		78
B. BELKE		76.1		82
M. BELKE		70.3		87
R. ENNS		73.6		80
N. KUCHER		96.8		112
D. MARTIN		71.6		82
D. NAHORNIAK		65.6		72
D. PAWLUK		66		75
D. SMALL		82.2		98
P. SZASZKIEWICZ°				81
J. WORKUM		74.2		86
L. YUEN		66.6		80.0
G. SPENCER °				90
MEANS		73.8		84.7
S.D.		8.66		10.8

° Excluded from analysis.

TEST ITEM: Height

Recorded in Cm

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		145.2		14.8
B. BELKE		146.0		151.1
M. BELKE		145.3		151.7
R. ENNS		137.1		142.2
N. KUCHER		145.5		153.0
D. MARTIN		143.5		149.2
D. NAHORNIAK		135.3		142.2
D. PAWLUK		141.0		147.3
D. SMALL		148.6		158.1
P. SZASZKIEWICZ°				144.8
J. WORKUM		145.0		152.9
L. YUEN		137.1		148.6
G. SPENCER °				149.9
MEANS		142.7		149.2
S.D.		4.19		4.66

° Excluded from analysis.

TEST ITEM: PWC_{170}

Recorded in Kpm/min

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		420.7		560.8
B. BELKE		566.6		613
M. BELKE		487.4		620.9
R. ENNS		444.2		622.1
N. KUCHER		562.9		651.1
D. MARTIN		400.1		461
D. NAHORNIAK		381.7		458.6
D. PAWLUK		496.3		518.5
D. SMALL		451.6		627.0
P. SZASZKIEWICZ°				729.9
J. WORKUM		413.9		599.7
L. YUEN		457.8		505.6
G. SPENCER °				687.5
MEANS		462.1		567.1
S.D.		58.5		66.7

° Excluded from analysis.

TEST ITEM: PWC_{170}/Kg

Recorded in Kpm/min

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		13.5		15.9
B. BELKE		16.5		16.6
M. BELKE		15.3		15.8
R. ENNS		13.3		17.2
N. KUCHER		12.9		12.9
D. MARTIN		12.4		12.5
D. NAHORNIAK		12.9		14.1
D. PAWLUK		16.7		15.3
D. SMALL		12.1		14.2
P. SZASZKIEWICZ°				20.0
J. WORKUM		12.4		15.5
L. YUEN		15.3		14.0
G. SPENCER °				31.5
MEANS		13.9		14.9
S.D.		1.62		1.42

° Excluded from analysis.

TEST ITEM: Grip Strength - Left

Recorded in Kg

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		14		18.5
B. BELKE		20		24
M. BELKE		19		28.5
R. ENNS		20		29.0
N. KUCHER		24		32
D. MARTIN		19		23
D. NAHORNIAK		18		22.0
D. PAWLUK		17		20.0
D. SMALL		19		26
P. SZASZKIEWICZ°				30.0
J. WORKUM		26		31
L. YUEN		16		22.0
G. SPENCER °				31.5
MEANS		19.3		25.1
S.D.		3.2		4.3

° Excluded from analysis.

TEST ITEM: Grip Strength - Right

Recorded in Kg

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		16		22.0
B. BELKE		20		27.5
M. BELKE		20		28.0
R. ENNS		18		26.0
N. KUCHER		23		32
D. MARTIN		20		26.5
D. NAHORNIAK		15		21
D. PAWLUK		17		20.0
D. SMALL		21		30
P. SZASZKIEWICZ°				30.5
J. WORKUM		24		33
L. YUEN		18		28.0
G. SPENCER °				31.5
MEANS		19.3		26.7
S.D.		2.67		4.08

° Excluded from analysis.

TEST ITEM: Shuttle Run

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		12		12.5
B. BELKE		11.8		11.4
M. BELKE		11.6		11.5
R. ENNS		11.6		12.1
N. KUCHER		12.9		12.4
D. MARTIN		11.9		12.5
D. NAHORNIAK		11.8		11.7
D. PAWLUK		12.0		12.8
D. SMALL		12.2		12.1
P. SZASZKIEWICZ°				11.4
J. WORKUM		12		11.1
L. YUEN		11.9		11.0
G. SPENCER °				12.3
MEANS		11.9		11.9
S.D.		.339		.584

° Excluded from analysis.

TEST ITEM: Standing Broad Jump

Recorded in Inches

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		63		54
B. BELKE		67		70.5
M. BELKE		67		74
R. ENNS		61		62.0
N. KUCHER		61		68
D. MARTIN		64.0		66.5
D. NAHORNIAK		63		54
D. PAWLUK		66		61.5
D. SMALL		67.0		69.5
P. SZASZKIEWICZ°				66.5
J. WORKUM		71		68
L. YUEN		66		73.0
G. SPENCER °				61
MEANS		65.1		65.6
S.D.		2.88		6.58

° Excluded from analysis.

TEST ITEM: Flex Arm Hang

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		26		56.0
B. BELKE		36		45.5
M. BELKE		29		12.0
R. ENNS		60		62.0
N. KUCHER		48		32.5
D. MARTIN		66.0		39.0
D. NAHORNIAK		71		65.0
D. PAWLUK		91		67.0
D. SMALL		53		32
P. SZASZKIEWICZ°				20.0
J. WORKUM		42		48.0
L. YUEN		30		60.0
G. SPENCER °				28.0
MEANS		50.2		47.2
S.D.		19.47		16.31

° Excluded from analysis.

TEST ITEM: Sit Ups

Recorded in Number

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		45		46
B. BELKE		45		46
M. BELKE		38		59
R. ENNS		38		39
N. KUCHER		37		40
D. MARTIN		36		40
D. NAHORNIAK		52		48
D. PAWLUK		36		39
D. SMALL		47		46
P. SZASZKIEWICZ°				30
J. WORKUM		62		58
L. YUEN		32		47
G. SPENCER °				50
MEANS		42.6		46.2
S.D.		8.36		6.66

° Excluded from analysis.

TEST ITEM: 50 Yards

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		8.5		8.6
B. BELKE		8.4		8.3
M. BELKE		7.6		7.5
R. ENNS		8.1		8.5
N. KUCHER		8.6		8.1
D. MARTIN		8.8		8.5
D. NAHORNIAK		7.8		8.2
D. PAWLUK		8.1		8.2
D. SMALL		8.2		8.2
P. SZASZKIEWICZ°				7.6
J. WORKUM		7.4		7.8
L. YUEN		8.0		7.8
G. SPENCER °				7.9
MEANS		8.1		8.2
S.D.		.407		.323

° Excluded from analysis.

TEST ITEM: 300 Yards

Recorded in Seconds

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		65.9		69.0
B. BELKE		65.7		63.2
M. BELKE		62.8		62.9
R. ENNS		68.9		67.5
N. KUCHER		68.8		64.3
D. MARTIN		66.1		69.2
D. NAHORNIAK		65		68.5
D. PAWLUK		64.2		65.5
D. SMALL		67.1		64.0
P. SZASZKIEWICZ°				62.8
J. WORKUM		64.1		61.2
L. YUEN		67.0		60.0
G. SPENCER °				66.4
MEANS		65.9		65.0
S.D.		1.83		3.03

° Excluded from analysis.

TEST ITEM: Predicted MVO_2

Recorded in ml/Kg/min

CONTROL
GROUP

SUBJECT	1975-76 Pre	1975-76 Post	1976-77 Pre	1976-77 Post
D. BLADE		43.0		50.8
B. BELKE		52.6		62.8
M. BELKE		48.9		50.4
R. ENNS		42.6		54.9
N. KUCHER		41.1		41.1
D. MARTIN		39.5		39.7
D. NAHORNIAK		41.1		45.0
D. PAWLUK		53.1		48.9
D. SMALL		38.8		45.2
P. SZASZKIEWICZ°				
J. WORKUM		48.6		44.7
L. YUEN		48.6		44.7
G. SPENCER °				
MEANS		44.4		47.5
S.D.		5.12		4.56

° Excluded from analysis.

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